Northumbria Research Link

EVALUATION OF A SOCIAL HOUSING RETROFIT PROJECT AND ITS IMPACT ON TENANT ENERGY USE BEHAVIOUR

DAVID MARK LOWERY

A thesis submitted in partial fulfilment
of the requirements of the
University of Northumbria at Newcastle
for the degree of
Doctor of Philosophy

Research undertaken in the
School of Built and Natural Environment
and in collaboration with
Gentoo Group Ltd, Sunderland

January 2012

Declaration

I declare that the work contained in this thesis has not been submitted for any other award and that it is all my own work. All other sources of information used, have been acknowledged.

Name: David Lowery

Signature:...

Date:...

Dedication

To Roland Rutter (1925-2011)

My Grandad

Acknowledgements

I must first thank the tenants involved with this research, by volunteering their knowledge and experiences, they provided an insight into their daily lives which formed the backbone of this thesis.

Abstract

Retrofit programmes for installing energy efficient technologies in social housing are a key part of efforts to reduce UK carbon emissions by 80 per cent by 2050. This requires a reduction in CO_2 emissions by an average of 80%, from all housing, in order to assist the UK's long term goals. The UK's turnover of housing stock is relatively slow compared to most developed countries and approximately 87% of the current housing stock will still be standing in 2050. Therefore, to meet carbon emissions targets, existing buildings must be refurbished or 'retrofitted' with technologies which reduce carbon emissions on a huge scale. The Government intends to achieve this by driving energy efficiency in households and businesses predominantly through the proposed Green Deal framework. This represents a shift in policy approach since the 2010 elections, towards a private finance and private industry approach, as rather than the previous Labour Governments predominately state managed and grant-aided social retrofit approach. The influence of the economic recession at the time of this transition is also likely to be a key driver of the Governments changing approach to financing the retrofit of millions of UK homes. Other strategies such as the UK Fuel Poverty Strategy are also intended to dove-tail with this national push to retrofit housing stock, due to reduced energy costs and increased thermal comfort. There is great potential for the proposed national retrofit mobilisation to reduce carbon emissions from homes, contribute to economic growth and provide other benefits such as the reduction of Fuel Poverty. However, the amount of energy used in homes is largely dependent on the behaviours of the occupier(s) and occupant behaviour can determine the effectiveness of retrofit programmes and thus impact on the potential of this significant mobilisation to reduce energy consumption and carbon emissions from housing. Thus, occupant behaviour is increasingly recognised as a critical element to be acknowledged and addressed in order to meet carbon reduction targets, both within the literature (excluding the policy literature) by and those delivering retrofits on the ground. This research provides a unique insight into occupant energy use behaviour by evaluating a 'live' project to retrofit energy efficient being implemented by Gentoo Group which includes construction and social landlord roles. The literature review relevant to the research focuses on Psychological theories of behaviour and Practice Theory. This provides insights from both paradigms provide two viewpoints on behaviour: an insight into the nature of individual behaviour (Psychological theories of behaviour), and; a consideration of how the framework and structure of society (including aspects such as technology) interacts with the

individual's practices (Practice Theory). The research methodology utilised an inductive approach, underpinned by a qualitative research design. In-depth interviews were conducted before and after specific interventions (a technical intervention and informational interventions) took place, these interviews were recorded and transcriptions were thematically organised and analysed using the template analysis technique. This process first identified 'patterns of behaviour related to energy use' arising due the project interventions and secondly based on the frequency of these occurring, identified 'key patterns'. The theoretical perspectives of the Psychology and Practice Theory literature were drawn on in order to contextualise the findings of the research, but it this thesis does not attempt to apply them in an empirical approach. The analysis process instead draws on specific elements from both of the disciplines to assist the interrogation of the 'key patterns' so they may be better explained or understood. Key findings of the research highlighted that energy use behaviour is impacted by the introduction of technology, and tenant behaviour can potentially impact on the energy saving effectiveness of retrofit projects. Significant impacts were identified specifically where tenants had an interaction with the technology being introduced and the informational intervention had no significant impact on behaviour. 'Key patterns' indicated several factors which influence tenant energy use behaviour and of these the barriers to retrofit effectiveness were identified as: limited access to knowledge and skills; habits preventing behaviour change to utilise introduced technologies; the quality of installation and function of the technical intervention; convenience of introduced technology potentially increasing energy use, and: the need or desire for thermal comfort. The thesis concludes that energy use behaviour is pivotal factor in determining retrofit effectiveness and that behaviour, and in particular behaviour-related barriers to retrofit effectiveness, should be acknowledged and addressed as part of the UK retrofit strategy, especially in the light emerging policies such as the Green Deal and Energy Company Obligation, which intend to drive retrofit on a huge scale. Recommendations are made inform retrofit practitioners and academic and policy debates on behaviour in the context social housing retrofit, and suggestions are made for future research to explore this research area further.

Contents

List of Tables

List of Figures

Appendices

1. Introduction

1.1 Introduction

1.1.1 The UK Strategy for Low-Carbon Housing

By 2050, the UK is committed to reducing carbon emissions by 80 per cent lower than the net baseline in the year 1990 (Climate Change Act, 2008). In the UK, housing is responsible for 27 per cent of national carbon dioxide (CO_2) emissions (Boardman, 2007a), through the provision of heating, cooking, lighting, and electrical power for appliances (Palmer and Cooper, 2011). Housing stock in the UK is amongst the least energy efficient in Europe (POST, 2005). As new-build housing only represents one per cent of the building stock each year (DCLG, 2006a), in order to meet carbon emissions targets, existing buildings must be refurbished or 'retrofitted' with technologies which reduce carbon emissions on a huge scale. This requires a reduction in CO_2 emissions by an average of 80%, from all housing, in order to assist the UK's long term goals (EST, 2010a). The Energy Saving Trust (2010a) has estimated that about 24 million homes, that either exist now or are built before 2016, will still exist in 2050. Therefore, on average 600,000 homes per year, or about 12,000 per week will need to be refurbished with energy saving and low carbon technologies in the next four decades, to meet the 80% emissions target.

The current Government has set out plans to reduce emissions from energy supply, by establishing low carbon technologies including renewable power, a new generation of nuclear power and clean fossil fuels using carbon capture and storage. The Government also aims to reduce demand for energy across the economy, increase efficiency and to reduce wasted energy. It states it's priority is to:

> *"Reduce energy use by households, businesses and the public sector*
> *and to help protect the fuel poor"* (DECC, 2011a, p. 3)

The Government intends to achieve this by driving energy efficiency in households and businesses though the Green Deal, using energy more effectively through a smart electricity and gas meter roll out, and supporting vulnerable customers in meeting energy bill costs (DECC, 2011a). Green Deal is a framework to enable private firms to offer consumers energy efficiency refurbishments or retrofits to their homes, community spaces and businesses at no upfront cost, and to recoup payments through a charge in instalments on the energy bill (DECC, 2010b). This financial incentive mechanism, is currently the key mechanism which is intended to mobilise the energy efficient and low carbon retrofit of the UK's 24 million homes.

The challenge of delivering low-carbon retrofit on unprecedented scales has also been recognised by the Government as an opportunity in the context of the current recession, as the jobs and trade created by the process are intended to boost economic recovery (Environmental Audit Committee, 2011a). The Government has argued that in order to ensure sustainable economic growth, the UK needs a third industrial revolution: a 'green revolution' (DECC, 2010a) which will lead towards a low-carbon future, with cleaner energy and greener growth. Addressing the inefficiency of housing is a key objective in the Government's two-fold strategy of economic growth and carbon reduction which policy programmes such as the proposed Green Deal are expected to deliver (DECC, 2010a). Programmes such as these aim to mobilise private capital at scale to invest in green infrastructure and are expected to employ a 'low-carbon army' to design and develop low carbon systems and retrofit the UK's homes and businesses (Environmental Audit Committee, 2011b).

Other strategies such as the UK Fuel Poverty Strategy are also intended to dove-tail with this national push to retrofit housing stock, due to reduced energy costs and increased thermal comfort (DECC, 2011a). A household in Fuel Poverty is one that needs to spend more than 10% of its income on all fuel use and to heat the home to

an adequate standard of warmth. Energy efficiency measures such as the installation of insulation have had an impact on Fuel Poverty by reducing costs and improving thermal comfort (Warm Front, 2011). Wide-scale retrofit programmes also provide the potential to have the same impact through efficiency improvements and improving the fabric of homes.

There is great potential for the proposed national retrofit programme to reduce carbon emissions from homes, contribute to economic growth and provide other benefits such as the reduction of Fuel Poverty. However, the amount of energy used in homes is largely dependent on the behaviours of the occupier(s) (Smith and Pett, 2005; Janda, 2009; Gill et al., 2010; Stevenson and Leaman, 2010) and the importance of occupant behaviour in determining the effectiveness of retrofit programmes should not be ignored during this significant mobilisation to reduce energy consumption and carbon emissions from housing (LCEA Behaviour Change Retrofit Group, 2011).

1.1.2 The Retrofit Approach

For the purposes of this thesis the term 'retrofit' will be used to refer to any type or collection of works, refurbishment, measures, technology installations or applications, which are directed at existing housing stock with an aim to significantly improve the energy efficiency and/or reduce the carbon emissions of the existing housing stock. A retrofit project usually targets existing housing stock which has relatively poor energy efficiency rating, using models such as the Standard Assessment Procedure (see section 2.2.1). In order to intervene to improve energy efficiency and reduce CO_2 emissions, retrofit technologies (e.g. insulation, draft proofing, 'A' rated condenser boilers, heating controls, double glazed windows, showers, and/or other low-carbon, renewable, energy efficient or micro-generation technologies) are installed (RIBA, 2011a; RIBA, 2011b). An 'effective' retrofit in the context of meeting carbon reduction targets would significantly reduce the carbon emissions of a home, aiming for 80% reduction in CO_2 emissions (EST, 2010a), without compromising thermal comfort (WHO, 2007).

The space heating and water heating account for a large proportion of the carbon emissions from UK households through the use of gas or electricity for heating, both sourced predominantly from fossil fuels burned directly (in the case of gas) or indirectly (in the case of fossil fuel powered electricity generation). The assumption

is that energy efficient technologies retrofitted to housing will reduce energy consumption, carbon emissions and fuel costs, however the home occupants' behaviour related to energy use will influence these factors (Smith and Pett, 2005; Janda; 2009; Gill et al., 2010; Stevenson and Leaman, 2010; Morley and Hazas, 2011).

The actual effectiveness and impact of Technical Intervention on energy use and carbon emissions may be miscalculated without taking into account occupant behaviours associated with energy consumption, because alterations in occupant behaviours are difficult to predict (Leaman, et al., 2010; Morley and Hazas, 2011). Thus, occupant behaviour is increasingly recognised as a critical element to be acknowledged and addressed in order to meet carbon reduction targets, both within the literature (Gill et al., 2010; Stevenson and Leaman, 2010) and by those delivering retrofits on the ground (Gentoo Group, 2008a; LCEA Behaviour Change Retrofit Group, 2011). Evidence has shown that occupant behaviours related to energy use impact on the potential of energy efficient technology. For example, energy efficiency potential is reduced by the comfort 'takeback' effect (Milne and Boardman, 2000), the installation of energy efficient technology may lead to a 'rebound' effect, and people may use energy efficient appliances more often, because they are energy efficient (Hertwich, 2005). Factoring in aspects of occupant behaviours into the future retrofit programmes is thus essential, in order to identify how occupant behaviour may impact on energy saving and carbon reduction potential, so they can be addressed. In this context, the focus of this research is particularly relevant as the retrofit of technologies through mechanisms such as Green Deal or the Energy Company Obligation (ECO), may impact on occupant behaviour related to energy use and thus create a positive or negative impact on energy saving potential.

A programme of physical retrofit activity can improve the energy efficiency of existing homes and reduce carbon emissions, however the behaviour of occupants in homes ultimately decides the amount of energy used and related carbon emissions. As Janda (2009) states:

> *"...buildings don't use energy, people do."* (p. 3)

A building's overall energy efficiency may be improved compared before the retrofit, but the behaviours of occupants may result in unexpected outcomes: increasing energy use and carbon emissions (nullifying the impact of the retrofit); or decreasing

energy use and emissions (enhancing the impact of the retrofit). Thus, understanding the interaction between occupier behaviour and energy efficient retrofits is crucial, if retrofit programmes are to be deployed effectively, in order to meet UK emissions targets.

Without an effective approach to address behaviour, the huge UK retrofit mobilisation could fail to deliver its potential and miss the opportunity to meet emissions targets. This will result in negative impacts, both from the perspective of the individual householder's energy bills and in terms of achieving national CO_2 emissions targets.

When compared to the existing attention given to physical retrofit measures, retrofit policy makers and programme implementers (such as Registered Social Landlords), have only recently started to pay attention to the influence of occupant behaviour. Research into behaviour related to energy use in the context of housing retrofits can inform policy makers and retrofit programme implementers and thus assist in the development of retrofit programmes which incorporate this critical component.

Occupants of buildings are recognised as one of the best instruments for measuring housing performance, even if they are hard to calibrate (Cole et al., 2008), and their feedback can quickly demonstrate why a technology does or does not work. Important feedback provided by the occupants as they inhabit their homes can be input into improving the modelling and design of housing as well it's management and maintenance in order to reduce energy use and carbon emissions (Stevenson and Leaman, 2010).

A significant financial investment will be required to mobilise retrofit activities as part of the UK strategy for low carbon housing. Much of the capital of this investment will be drawn from the public purse, through for example mechanisms such as the Green Deal (see section 2.2.1) or levies on domestic energy bills, such as the Energy Company Obligation (ECO) which comes into force in 2013. The increasing risks associated with climate change strengthen the imperative of achieving low-carbon housing as part of the UK Carbon Reduction Strategy. Also, there are opportunities for a national retrofit mobilisation, to bring social benefits, such as the reduction and potential eradication of Fuel Poverty. Considering the above factors, it appears that the stakes are high to achieve success in the national mobilisation to retrofit the UK's homes, especially considering that it will take decades to complete

and cannot be easily corrected or started over. Therefore it is very important that the UK's national retrofit programme is conducted in a way that maximises overall effectiveness (i.e. energy saving potential and carbon reduction). Thus any contribution to knowledge on the crucial component of behaviour is valuable and worthwhile in this enormous effort to improve the energy efficiency of the UK's existing housing stock, through widespread retrofit measures.

This thesis aims to inform academic and policy debates on behaviour in the context of a social housing retrofit, by evaluating the impacts of a practical retrofit project on tenant behaviour related to energy use, and identifying behaviour-related barriers to retrofit effectiveness.

1.2   Researching a 'Live' Retrofit Project

This PhD research was conducted in collaboration with Gentoo Group, an organisation which describes itself as a 'people, planet and property company' and is an association of organisations which involves a Registered Social Landlord, Gentoo Group Sunderland. The collaboration with Gentoo Group (the Social Landlord arm of which manages approximately 30,000 rented homes around Sunderland in the North East of England) provided an opportunity to explore retrofit impacts on behaviour in a real-time setting.

Gentoo Group piloted and monitored the installation of new low-carbon energy saving solutions in a sample of 139 households, through a project entitled 'Retrofit Reality', funded initially by the Housing Corporation, before its succession by the Tenant Services Authority (TSA). In order to inform a roll-out programme for its housing stock and to inform the housing sector, the Retrofit Reality Project aimed to identify technological, economic and behavioural issues, which make the installation of energy-saving retrofit measures challenging.

The Gentoo Group project objectives focused on the feasibility of retrofit measures with particular attention given to supply chain and procurement; technical aspects of installation and maintenance; the effectiveness of measures in terms of energy savings; and real energy consumption data (opposed to theoretical assumptions). A further key objective of the project was to evaluate the impact of the retrofit technologies on tenant energy-use behaviours, the impact of energy advice in this

context and social and behavioural barriers which impact on retrofit effectiveness (i.e. energy-saving potential).

Gentoo Group co-funded a PhD studentship with the School of the Built and Natural Environment, at the University of Northumbria and the research to specifically address the behaviour-related objective was undertaken through this PhD. The PhD research therefore forms part of the wider Gentoo Group project, however it also goes further than the Gentoo Group objectives in its exploration of energy related behaviours.

1.3   Aims and Objectives of the PhD Research

In the context of retrofit project implementation in a social housing context, this PhD research aimed to:

- Evaluate the impacts of retrofit technologies on tenant behaviours related to energy use.

- Evaluate the impacts of written and verbal guidance on energy saving behaviours.

- Identify behaviour-related barriers to retrofit energy saving effectiveness.

The research objectives were to:

- Gather baseline data on tenant behaviour related to energy use:
    - Before the Technical Intervention
    - Before the Informational Intervention

- Gather follow-up data on tenant behaviour related to energy use:
    - After the Technical Intervention
    - After the Informational Intervention

- Analyse and compare baseline and follow-up data to determine impacts on behaviour and identify behaviour-related barriers to retrofit energy saving effectiveness.

1.4   Outline of Chapters

Chapter 2, outlines the UK policy context related to the energy efficient retrofit of social housing and behaviour related to energy use. It describes the various policies and Government initiatives that have been introduced in an attempt to address the

challenge of reducing the energy consumption and carbon emissions, from existing housing in the UK. Fuel poverty policy is discussed, along with policy frameworks for behaviour change in relation to climate change and energy use. Chapter 3, provides a review of the literature relevant to the research with a focus on Psychological theories of behaviour and Practice Theory. Drawing on these literatures the factors influencing behaviour related to household energy use are discussed. Chapter 4 provides a detailed explanation of the research design and methodology. The PhD research context is discussed and its impact on research design. Interventions evaluated by the research are explained, in addition to an outline of the data collection and analysis methods. Chapter 5 describes and evaluates the findings of the PhD research including discussions of 'patterns of behaviour related to energy use' and 'key patterns'. Chapter 6 provides conclusions, which include a summary of findings, recommendations, implications of the research, research limitations and suggestions for future research.

2. Policy Context

2.1 Introduction

Retrofit programmes for installing energy efficient technologies in social housing play an important part in the UK carbon reduction strategy (DECC, 2009a). If the interaction between occupants and retrofit technologies can be further understood in this context, social housing providers may be able to develop retrofit programmes where behavioural aspects are addressed, through for example an appropriately targeted communication programme. By evaluating the impacts of a social housing retrofit project on behaviour related to energy use, this thesis aims to improve understanding of behaviour related to energy use in this setting. It is anticipated that the findings will inform local, regional and national policy makers, retrofit practitioners (such as Registered Social Landlords), third sector organisations (such as National Energy Action) and open new avenues for future academic research.

The PhD research was conducted in collaboration with Gentoo Group (an organisation providing 30,000 social housing units around Sunderland). Gentoo Group's 'Retrofit Reality' project, upon which the PhD research is based, monitored the installation of new low and zero carbon energy solutions in a sample of 139 households. Through a series of 'before' and 'after' semi-structured interviews, the PhD research evaluated the impact on tenant behaviours associated with energy

consumption, related to the following interventions (see methodology, chapter 4, for more information):

▪ Technical Intervention (provision of energy-saving technology)

▪ Informational Interventions (provision of energy-related or environmental-related information), split into two types:

- Informational Intervention 1 ('before' and 'after' semi-structured interviews, conducted by the PhD researcher)

- Informational Intervention 2 (written and verbal guidance on energy saving behaviours, delivered by the PhD researcher, delivered in addition to informational intervention 1 at a point mid-way between the 'before' and 'after' semi-structured interviews)

The aim of this research was to evaluate the impacts of the above interventions on behaviour related to energy use, and identify behaviour-related barriers to effective energy efficient retrofits in a social housing setting. By drawing on evidence from householders who were experiencing the process of a retrofit project in a real-time setting.

Before discussing the retrofit project itself in more detail (see Chapter 4), it is important to set out the policy landscape relating to the retrofitting of existing housing stock, the role of Registered Social Landlords and behaviour change towards reducing energy consumption. This chapter outlines and evaluates the UK policy context related to the energy efficient retrofit of social housing and behaviour related to energy use. Section 2.2 describes the various policies and Government initiatives that have been introduced in an attempt to address the challenge of reducing the energy consumption and carbon emissions from existing housing in the UK. This shows the clear imperative that carbon dioxide emissions from UK housing need to be dramatically reduced in order to meet emission reduction targets. The core approach to achieving this is through the financially incentivised encouragement of the uptake of energy efficient and low carbon retrofit technologies. Through mechanisms such as the Green Deal, the Government is attempting to mobilise the retrofit of existing homes, nationally, over the next few decades. The intention is that this approach will reduce energy use and carbon emissions significantly enough to meet the 80% carbon reduction target. The danger of occupant behaviour impacting on retrofit energy saving potential may be recognised by policy makers, however there is no evidence that this is being

addressed. Fuel Poverty policy is discussed in Section 2.3 and it is suggested that some social dimensions of delivering policy to address carbon emissions have been overlooked. Delivery of national retrofit programmes is funded by inequitable levies on energy bills, thus not supporting the 'polluter pays' principle, and the policy mechanism intended to address Fuel Poverty does not target the most vulnerable households. Policy frameworks for behaviour change are explored in Section 2.4, which indicate a focus on encouraging or 'Nudging'' behaviour changes to purchase and retrofit energy efficient technologies, through financial incentives such as the Green Deal. Policy frameworks show less focus on actual behaviour related to energy use or lifestyles in the context of buildings, retrofitting or in general.

2.2   Policy Context

2.2.1   Retrofitting of Housing Stock

As already noted, 27% of the UK's total CO_2 emissions come from its housing stock (Boardman, 2007a) –approximately 26 million existing homes, yet these have attracted disproportionately less attention in the literature than the relatively small new-build sector. The Government has, in it's *'UK Low Carbon Transition Plan'* (DECC, 2009a) set a target of cutting emissions from homes by 29% (on 2008 levels) by 2020 and a range of policies have since emerged, aimed at meeting this target. Extensive refurbishment of existing homes is central to achieving a reduction in CO_2 emissions because the UK's turnover of housing stock is relatively slow compared to most developed countries and approximately 87% of the current housing stock will still be standing in 2050 (Boardman, 2007b).

Over the past decade or so, a suite of policies and Government initiatives have been introduced in an attempt to address the challenge of reducing the energy consumption and carbon emissions attributed to existing housing in the UK. They are as follows:

- The Decent Homes Standard

- Warm Front Scheme

- Warm Homes, Greener Homes: A Strategy for Household Energy Management

- Feed-In Tariff (FIT)

- Renewable Heat Incentive (RHI)

- Green Deal

- Community Energy Saving Programme (CESP)

- Carbon Reductions Targets (CERTs)

- Energy Company Obligation (ECO)

- Shaping Our Future (Third Sector Involvement)

Each of these policies are now examined in detail below.

The Decent Homes Standard

The Decent Homes Standard, operated by the Department for Communities and Local Government (DCLG) is the principle mechanism for improving existing housing, however it is limited to homes managed by Registered Social Landlords (RSLs), (referred to as 'Social Landlords' for the remainder of this thesis).

A 'decent home' meets the following four criteria:

a) It meets the current statutory minimum standard for housing
b) It is in a reasonable state of repair
c) It has reasonably modern facilities and services
d) It provides a reasonable degree of thermal comfort.
(DCLG, 2006b)

The latter requirement for a reasonable degree of thermal comfort (see, section 3.5.1), requires homes to have both effective insulation and efficient heating (DCLG, 2006b). The thermal comfort of a property is sometimes measured through the use of an energy efficiency rating known as SAP (Standard Assessment Procedure), which is a scale from 0 to 100 (100 being excellent). SAP has been adopted by Government as part of the UK national methodology for calculation of the energy performance of buildings (BRE, 2009).As outlined in '*The Government's Standard Assessment Procedure for Energy Rating of Dwellings, 2005 edition, revision 3'* (BRE, 2009), the calculation takes into account a range of factors that contribute to energy efficiency and include:

- *"Materials used for construction of the dwelling*

- *Thermal insulation of the building fabric*

- *Ventilation characteristics of the dwelling and ventilation equipment*

- *Efficiency and control of the heating system(s)*

- *Solar gains through openings of the dwelling*

- *The fuel used to provide space and water heating, ventilation and lighting*

- *Renewable energy technologies*

The calculation is independent of factors related to the individual characteristics of the household occupying the dwelling when the rating is calculated, for example:

- *Household size and composition;*

- *Ownership and efficiency of particular domestic electrical appliances;*

- *Individual heating patterns and temperatures."*(p. 6)

Trends in SAP rating of domestic properties in England shows that, although social landlord properties are in a relatively better condition than privately rented or owned properties (by April 2009 it was reported that 86% of homes in the social sector were 'decent' (National Audit Office, 2010)), there is still room for a reduction in CO_2 emissions through a range of energy efficiency measures and low carbon technologies (DCLG, 2010).

Warm Front Scheme

The Warm Front Scheme provides heating and insulation improvements to households on certain income-related benefits living in properties that are poorly insulated and/or do not have a working central heating system. The Scheme began in June 2000 (BRE, 2008) and was suspended in December 2010 (Warm Front, 2011), before accepting new applications on 14 April 2011 with a new set of eligibility criteria. The Scheme is now targeted at people on certain income-related benefits and living in properties that are poorly insulated and/or do not have a working central heating system. It is only available in England and applicants must own their home or rent it from a private landlord, thus Social Housing tenants are not eligible (Directgov, 2011).

Qualifying households can get improvements worth up to £3,500 (£6,000 where oil central heating and other alternative technologies are recommended).Grants are available for improvements such as:

- Loft insulation

- Cavity wall insulation

- Draughtproofing

- Gas, electric, liquid petroleum gas or oil heating

- Hot water tank insulation

- Glass-fronted fire - conversion of solid-fuel open fire to a glass-fronted fire

(Directgov, 2011)

Since the start of the Scheme 2.3 million households have received measures (Warm Front, 2011). Table 1, below, shows a breakdown of the number of measures delivered to homes from the beginning of the Scheme until 2010:

Table 1: Measures delivered through the warm front scheme from 2000-2010

Measure type	Number of measures
Cavity Wall Insulation	489,961
Draughtproofing	576,294
Electric Central Heating	73,154
Factory Insulated Dual Immersion Hot Water Tank	8,631
Gas Wall Heaters	24,697
New Gas Central Heating	185,487
Hot Water Tank Jackets	157,867
Loft Insulation	720,985
Boiler Replacements	454,828
Heating Repairs	114,686
Oil Central Heating	3,791

(Adapted from: Warm Front, 2011)

Warm Homes, Greener Homes

The previous Labour Government's '*Warm Homes, Greener Homes: A Strategy for Household Energy Management'*(DECC, 2010c) sets out the Government's Strategy to work with people to make their homes more comfortable in winter, reduce energy use and make greater use of small scale renewable and low carbon sources of energy. The Government stated its ambition that by 2020:

- *"every home where it is practical will have loft and cavity wall insulation – an ambition we intend to deliver on by 2015;*

- *every home in Britain will have a smart meter and display to help them better manage their use of energy;*

- *up to 7 million households will have had an eco-upgrade which would include advanced measures such as solid wall insulation or heat pumps alongside smart meters and more basic measures;*

- *people living in rented accommodation will enjoy higher levels of energy efficiency as landlords – private and social – take action to improve the fabric of properties;*

- *there will be wider take up of district heating in urban areas, such as in blocks of flats, in new build and social housing, and in commercial and public sector buildings; and*

- *there will be a core of up to 65,000 people employed in the new industry of energy efficiency, and potentially several times more down supply chains. Jobs will include installing energy saving measures and providing home energy advice."*

(DECC, 2010c, p. 5)

In the document the Government stated the importance of understanding and engaging with customers, to stimulate demand for retrofit energy efficiency measures from householders, ensure that people use new technologies in the right ways, and facilitate general change in how people use energy in their homes. The Government proposed to do this by:

- Making the best use of existing initiatives and information sources that can influence behaviour change

- Building a detailed evidence base on the effective engagement of households and communities in carbon reducing behaviours and impacts this may achieve

- Using smart meters as an opportunity to engage with households on energy performance of their home.

(DECC, 2010c)

This strategy for household energy management set out by the previous Government is similar in many respects to the subsequent Coalition Government's approach, whereby the retrofit of energy efficient and low carbon technologies to existing homes is intended to significantly reduce energy use and carbon emissions from UK housing. To encourage the mobilisation required to retrofit 24 million homes in the next 39 years (EST, 2010a), energy efficient and low carbon retrofit technologies are incentivised mainly through financial mechanisms such as the

Feed-In Tariff, Renewable Heat Incentive, and the Green Deal, which are discussed below.

Feed-In Tariff

The UK Government Feed-In Tariff (FIT) was introduced in April 2010, under the Energy Act (2008) for electricity in order to make smaller scale micro-generation in domestic properties more financially attractive (Bergman et al, 2009). It is the aim of the FIT scheme to encourage the deployment of small scale (under 5MW) low carbon electricity generation, particularly by organisations, businesses, communities and individuals who are not traditionally engaged in the electricity market. FITs are intended to encourage people to invest in small scale low carbon electricity, in return for a guaranteed payment for the electricity they generate and export (DECC, 2011b). Most domestic technologies (and larger systems up to 5 megawatts) qualify for the FIT, including:

- Micro combined heat and power (CHP)

- Solar electricity (PV) (roof mounted or stand alone)

- Wind turbines (building mounted or free standing)

- Hydroelectricity

- Anaerobic digesters.

(EST, 2011)

The Government intends the FIT scheme to be easier to understand and have more predictable returns than the Renewables Obligation (RO). RO is a proposed regulatory measure, aimed at large scale energy generation companies to increase the generation of renewable electricity, from a range of technologies and a range of scales (DECC, 2011c). Between the start of the FIT scheme in April 2010 and June 2011 over 40,000 FIT installations were accredited, the vast majority at household level (DECC, 2011b). A number of Social Landlords have taken up FITs for housing stock, however uptake has been affected by overlapping policies such as the rules governing the combination of FITs and grants for works (DECC, 2011b). FITs work alongside the RO and the Renewable Heat Incentive (RHI) which, when implemented, will support generation of heat from renewable sources at all scales.

Renewable Heat Incentive

The UK Government has proposed a Renewable Heat Incentive (RHI) for launch in November 2011 (DECC, 2011d). The RHI provides financial support that encourages individuals, communities and businesses to switch from using fossil fuel for heating, to renewable energy sources such as biomass. The RHI is similar to the FIT scheme, whereby homeowners who install renewable technologies receive an annual payment for each kWh of energy generated. While FITs pay incentives for electricity-generating renewables, the RHI does so for those which generate heat. Annual payments will be made based on estimated figures dependent on the amount of energy needed to warm the building and will vary by house age and size as well as by technology (DECC, 2011e).

The Government is taking a phased approach to implementing the RHI. In the first phase, long-term tariff support will be targeted towards big emitters in the non-domestic sector. As part of the first phase, the Government will also introduce 'Renewable Heat Premium Payments' for the domestic sector. Government funding of around £15 million is reserved for premium payments to households who install renewable heating. These direct payments will subsidise the cost of installing qualifying renewable heating systems. In return for the payments, participants will be asked to provide feedback on how the equipment works in practice and suppliers will be asked to provide a follow up service on any issues that are raised. This aims to boost confidence in the technology and the information to improve Government, manufacturer's, installer's and consumer's understanding in order to maximize the performance of the various technologies (DECC, 2011e). The technologies considered eligible for the non-domestic phase (phase one) of RHI are as follows:

- Biomass boilers (Including CHP biomass boilers)

- Solar Thermal

- Ground Source Heat Pumps

- Water Source Heat Pumps

- On-Site Biogas combustion

- Deep Geothermal

- Energy from Municipal Solid Waste

- Injection of biomethane into the gas grid.

(DECC, 2011f)

A second phase of RHI support including long-term tariff support for the domestic sector is planned for introduction in 2012 to coincide with the introduction of the Green Deal. This phase will also establish other technologies and fuel uses that could not be included in phase one (DECC, 2011f). People in receipt of the 'Renewable Heat Premium Payments' will be able to receive long term RHI tariff support (20 years) once these tariffs are introduced (DECC, 2011e). As part of this second phase Social Landlords will receive support for domestic installations. In order to receive support they will need to be the owner of the installation and retain the rights and liabilities of the equipment (DECC, 2011f).

Green Deal

The Coalition Government recently proposed a 'Green Deal' for tackling household CO_2 emissions (DECC, 2010b), which is a flagship policy of the Energy Act (2011). In many respects the Green Deal is a continuation of the work by the previous Labour Government, building on the Pay As You Save (PAYS) scheme announced in 2009 and developed under a pilot scheme, testing a range of financing repayment options (DECC and EST, 2011). The PAYS pilot and Green Deal are principally the same concept –they provide financial incentives to encourage householders to install energy efficient and low carbon technologies in their homes, by loaning upfront costs for repayment over a long period. Energy efficiency in homes is improved, energy bills are reduced and this provides scope to pay back loans alongside bills with the intention that total charges are lower than the energy bills were before retrofit.

The Green Deal is anticipated to be launched in Autumn 2012 (DECC, 2010b). Under the powers of the Energy Act (2011) the Green Deal provides a framework to enable private firms to offer consumers energy efficiency improvements to their homes, at no upfront cost, and gather the debt for the cost of the improvement through a charge in instalments on the energy bill. This will be achieved through a 'Green Deal plan', a finance mechanism which allows consumers to pay back through their energy bills, with clear and transparent charges. The Green Deal differs from existing lending because the financial obligation is not attached to the individual, if the individual moves out of the home the financial obligation moves to the next bill payer at that property (DECC, 2010b). The following are prerequisites for all Green Deal plans, and are intended to protect consumers as outlined in '*The Green Deal: A summary of the Government's Proposals'* (2010b):

1. *"**The expected financial savings must be equal to or greater than the costs attached to the energy bill**, known as "the golden rule" of the Green Deal.*

2. *The **measures must be approved** and the claimed bill savings must be those accredited through this process.*

3. *The measures installed must have been recommended for that property by an **accredited, objective adviser** who has carried out an assessment.*

4. *The measures must be installed by an **accredited installer**.*

5. *For householders, the Green Deal provider must give appropriate advice within the terms of the **Consumer Credit Act** and take account of the individual circumstances of the applicant.*

6. *The Green Deal provider must have **consent** from the relevant parties, including the express consent of the current energy bill-payer.*

7. *The presence of a Green Deal must be **properly disclosed to subsequent billpayers (e.g. new owners or tenants)** alongside energy performance information.*

8. *Energy suppliers must collect the Green Deal charge and pass it on within the existing **regulatory safeguards** for collecting energy bill payments – including protections for vulnerable consumers."* (p. 5, bold is their emphasis)

Social Landlords will be able to deliver Green Deal to their tenants and leaseholders. '*Green Deal Potential in Social Housing'* a report by Camco (2011) on behalf of the National Housing Federation (NHF), has examined the potential for the Green Deal to deliver viable CO_2 reductions in the social housing sector (local authority and housing association homes) by examining what measures could be carried out according to the Green Deal 'Golden Rule' (i.e. the energy savings will pay for the measures over 25 years). Table 2, below, shows the reports key findings:

Table 2: Potential for CO_2 reduction in social housing through the Green Deal

CO₂ reduction potential	To achieve further savings on these homes:
Homes with low Green Deal potential Over 3 million homes fall under the category of low Green Deal potential, between them accounting for just 22% of the sector's overall total emission reduction potential (around 900,000 tonnes CO2). Capital investment per property ranges from £250-2000 with energy savings of less than 25%. These are properties that currently have relatively good levels of energy efficiency and for which many of the most cost-effective measures have already been installed.	FIT, RHI and ECO would need to subsidise measures: To reach £6.5k total investment per property this would cost an extra £17bn To reach £10k total investment per property this would cost an extra £28bn To reach £17k total investment per property this would cost an extra £49bn
Homes with medium Green Deal potential Nearly 400,000 homes fall under the category of medium Green Deal potential, accounting for 14% of the sector's overall emission reduction potential (around 600,000 tonnes CO2). Capital investment per property ranges from £2,500-10,000 with energy savings between 25% and 50%.	FIT, RHI and ECO would need to subsidise measures: To reach £6.5k total investment per property this would cost an extra £1bn To reach £10k total investment per property this would cost an extra £2bn To reach £17k total investment per property this would cost an extra £4bn
Homes with high Green Deal potential Nearly 800,000 homes fall under the category of high green deal potential, accounting for 64% of the sector's overall emission reduction potential (around 2.7 million tonnes CO2). Capital investment per property ranges from £5000-17,000 with energy savings between above 50%.	These homes would generally not require additional subsidy as they would achieve significant savings through the Green Deal alone.
Maximum potential of Green Deal in social housing The maximum potential of Green Deal measures which will pay for themselves over 25 years will achieve a 21% carbon reduction. A combination of Green Deal and grid decarbonisation could give a 32% reduction in emissions (around 12.5 million tCO2) in 2020. Capital investment will be around £12bn with annual energy bill savings of circa £1bn.	

(Adapted from Camco, 2011)

A target to reduce carbon emissions from UK homes by 29% by 2020, was set out in *'The UK Low Carbon Transition Plan'* (DECC, 2009a). Whilst it is acknowledged that this policy was introduced under the previous Government, if one assumes the social housing sector has the same target, then the findings in the above table suggest that it might be possible to meet the carbon emissions targets for 2020 (if the grid is decarbonised sufficiently). However, this is before considerations of occupier behaviour are factored into the calculations, such as comfort 'takeback' (see 3.5.1) which can impact on potential energy savings by up to 30% (Milne and Boardman, 2000). This is particularly relevant for energy efficiency retrofit programmes such as Green Deal as occupant behaviour factors such as these may impact on predicted energy savings.

Interestingly, when Camco's (2011) report factored in a realistic Green Deal potential, Green Deal would only provide a 4% carbon reduction by 2020. This was assuming that 25% of social housing received Green Deal retrofits and that there was a 25% loss of carbon reduction potential due the comfort 'takeback' effect.

It is also important to note that there are various limitations with using SAP software to calculate real energy and carbon savings. Results from 'Pay As You Save' (PAYS) pilot projects (DECC and EST, 2011) demonstrate that there is a significant difference between theoretical and actual energy and carbon savings, which can be much lower than predicted. This highlights an important issue regarding the use of SAP software and assumptions to predict actual energy and carbon savings, which may be a poor indicator of actual savings. This combined with occupant behaviour aspects such as comfort 'takeback' can have a significant impact on overall savings.

The National Housing Federation (NHF) has set up a Green Deal working group of housing association experts to assess the Green Deal proposals and identify barriers and solutions with an aim to ensure the Green Deal is feasible for all existing homes, including tenants and leaseholders in the social housing sector.

The latest *'Green Deal Working Group Report'* (NHF, 2011), highlights the following barriers and solutions to Green Deal feasibility for existing homes and social housing:

- **Landlord, Tenant and Leaseholder consent:** To ensure Green Deal can be delivered at scale, it is essential that the Government makes specific provisions for social landlords to gain consent to carry out Green Deal on their properties, particularly those in multi-occupancy, such as blocks of flats. The tenant should not be able to unreasonably refuse Green Deal work or refuse to pay associated charges if the Social Landlord or a majority of tenants request Green Deal. The Social Landlord should consult with tenants to allow them to make a fair representation.

- **Proposed Energy Company Obligation (ECO):** The role and correct administration of ECO is central to the success of the Green Deal. ECO should target energy efficiency improvements for fuel poor households and those in priority need. Remaining ECO should be used to treat 'hard to treat' properties, such as solid-walled homes. ECO should be transparent and available to all Green Deal providers and delivery agents to ensure a fair and competitive marketplace. Energy suppliers should make all costings transparent to ensure they do not maintain control over expenditure and monopolise the Green Deal Market. ECO and Green Deal should include the costs of delivering training and ongoing advice on behaviour change to ensure take-up and energy savings.

- **Measurement and assessment mechanism:** The household make-up and their energy consumption behaviour should be taken into consideration when carrying out Green Deal assessment. This is particularly important for households who currently under-heat their homes, such as households in Fuel Poverty. The role of encouraging take-up and behaviour advice must be recognised and accounted for in the Green Deal assessment. Assessment must be carried out by independent and accredited professionals.

- **Access to low cost finance and costs of works:** In order for Green Deal and the 'Golden Rule' to deliver appropriate savings to the social sector and encourage take-up, low cost finance must be made available.

- **Role of Renewable Energy:** Renewable energy and associated incentives such as FIT and RHI must be available and accessible alongside the Green Deal.

(NHF, 2011)

Community Energy Saving Programme (CESP)

The Government's Community Energy Saving Programme (CESP) targets households in areas of low income across the UK, aiming to improve energy efficiency standards and permanently reduce fuel bills (DECC, 2009b). CESP aims to achieve this through the delivery of up to £350m in energy efficiency measures (DECC, 2011g), funded through particular gas and electricity suppliers as part of an obligation to meet a carbon emissions reduction target. The CESP obligation period runs from 1 October 2009 till 31 December 2012. DECC is responsible for setting the overall CESP target and the policy framework, and Ofgem E-Serve is responsible for administering the programme. Ofgem has a legal requirement to report to the (then) Secretary of State for Energy and Climate Change on the CESP programme (Ofgem, 2011a).

A total of 142 schemes had been submitted to Ofgem by 31 December 2010. Qualifying measures include insulation, heating, district heating, behavioural (home energy advices package), and microgeneration (such as heat pumps, biomass boiler, solar thermal, solar PV and other microgeneration for heat or electricity). Estimated savings from all proposed schemes are calculated as 7.1 $MtCO_2$, representing nearly 37% of the overall CESP target (Ofgem, 2011a). So far a number of technical and administrative issues have arisen, mainly related to the complexity of the programme in comparison to CERT (see below) and issues with overlap between measures promoted under CERT and CESP leading to longer administration while procedures are put in place to prevent double counting (Ofgem, 2011a). Within '*Ofgems's Report on the Community Energy Saving Programme (CESP) 2009-2012, to 31 December 2010*' (2011a), there is no indication of the impact of CESP on the relief of Fuel Poverty or of the impact of the behaviour measures on energy savings.

Carbon Emissions Reduction Targets (CERT)

The Government has extended the Carbon Emissions Reduction Targets (CERTs) from March 2011 to December 2012 (DECC, 2011h), after which time energy companies will be obliged to take over the Green Deal policy, as set out within the Energy Security and Green Economy Bill (DECC, 2010d).

CERT which began in April 2008, is an energy and carbon saving scheme for the household sector, placing an obligation on energy suppliers to meet carbon reduction targets for households. Suppliers meet their targets by promoting (for

example, thorough subsidy) the take-up of energy saving measures, mainly loft insulation, cavity wall insulation and up till June 2010, low energy lighting (DECC, 2011h).

For April 2008 to March 2010 targets laid out under CERT (DECC, 2009b) by the Government were as follows:

- 185 $MtCO_2$ to be saved from the energy sector in the UK

- 50% of the saving to come from measures including installing loft and cavity wall insulation

- 2% of the target reduction to be achieved by microgeneration installations

- Face to face energy advice given in consultation with occupants

- Smart meters to be provided to occupants who request them.

The restructured CERT based on the above targets came into force on 30 June 2010, and the Government has acted to make the following changes to the scheme:

- Increasing the target by 108 Million lifetime tonnes of CO_2 and setting a new ambitious target of 293 $MtCO_2$

- Require obligated suppliers to meet 68% of the target through professionally installed insulation products

- Remove halogens and compact fluorescent lamps from the scheme

- Restrict microgeneration products to the most vulnerable groups only

- Encourage suppliers to promote solid wall insulation in off-gas grid properties

- Require written consumer request on all products promoted outside retail channels and to increase the innovation baseline to ensure that only the most innovative products receive incentives

- Require obligated suppliers to meet 15% of their total target within an ongoing 40% Priority Group target in a subset of low income households (a Super Priority Group) considered to be at high risk to Fuel Poverty.

(DECC, 2011h)

Local authorities and Social Landlords have been the primary mechanisms for the delivery of CERT (Ofgem, 2011b). Ofgem's '*Carbon Emissions Reduction Target Update, issue 13, September 2011*' (2011c) reported the following progress with CERT:

- *"207 Mt (lifetime) CO_2 emissions reductions achieved in CERT to date, including EEC2 carryover.*

- *This equates to 71% of the extended target of 293 Mt (lifetime) CO_2, 68% of the way through the programme.*

- *43% of total savings to date are from the Priority Group.*

- *62% of total savings to date are from insulation (including DIY loft insulation).*

- *25% of total savings to date are from lighting.*

- *14.4 Mt (lifetime) CO_2 achieved towards the new Insulation Obligation (IO) target of 73.4 Mt (lifetime) CO_2 (19.7%).*

- *1.5 Mt (lifetime) CO_2 achieved towards the new Super Priority Group (SPG) obligation target of 16.2 Mt (lifetime) CO_2 (9.3%)"* (p. 1).

To illustrate the types and distribution of measures installed through CERT, table 3, below shows the cumulative number of measures delivered by suppliers up to and including the thirteenth quarter (ending June 2011) of CERT, excluding measures carried over from Energy Efficiency Commitment 2 (EEC2). Figures are cumulative estimates and do not represent finalised figures.

Table 3: Measures delivered by suppliers through CERT up to June 2011

	Measure type	Number of measures
Insulation	Cavity wall insulation	1,674,655
	Loft insulation (excluding DIY insulation)	2,173,704
	Solid wall insulation	38,791
Heating	Fuel switching	73,319
Lighting	Compact Fluorescent Lamps (CFLs)	300,639,427
Microgeneration	Heat pumps	6,562
	Solar water heating (m2)	3,129
	Small scale Combined Heat & Power (CHP)	1
Behavioural	Real Time Displays (RTDs)	2,286,292
	Home Energy Advice Packages (HEAPs)	28,571

(Adapted from: Ofgem, 2011c)

It is important to note that a majority of measures were technology based rather than based on the delivery of energy advice and significantly more measures were delivered in Insulation Heating and Lighting than were delivered as behavioural measures.

Energy Company Obligation (ECO)

The 'Golden Rule', whereby expected savings from measures repay the costs, is central to Green Deal. There are some instances where the 'Golden Rule' will not be effective for certain householders or house types. The key mechanism to support in these cases will be the Energy Company Obligation (ECO) (DECC, 2011i). *'The Energy Act'* (2011) amends existing powers in *'The Gas Act'* (1986), *'The Electricity Act'* (1989) and *'The Utilities Act'* (2000) to enable the Government to create the ECO, which will:

- Supersede existing obligations to reduce carbon emissions (CERT and CESP) which expire at the end of 2012.

- Work in parallel with the Green Deal finance offer by targeting appropriate measures at those households likely to need additional support, in particular those with vulnerable people on low incomes and in hard-to-treat homes.

(DECC, 2011j)

It is the intention of the Government to apply ECO funding to both Fuel Poverty programmes and improvement to hard-to-treat homes in general. However, this has attracted criticism from organisations such as National Energy Action (NEA), a Fuel Poverty charity, and the Joseph Rowntree Foundation (JRF) a social policy research and development charity, both of which argue that the ECO should exclusively focus on vulnerable fuel-poor households. NEA and JRF (2011) reason that it would be a more equitable use of resources to target hard-to-treat properties occupied by the most financially disadvantaged in order to meet both social and environmental objectives.

Shaping Our Future (Third Sector Involvement)
As outlined thus far, the Government controls many of the levers needed to tackle climate change and other environmental issues successfully. However it recognises that a committed third sector is a necessary condition for successful action in the longer-term. Corresponding to this, the report by the Labour Government: *'Shaping Our Future'* (HM Government, 2010), contains a strategy for greater third sector involvement in climate change policies.

In 2010 the third sector was made up of 870,000 organisations, including charities, voluntary and community organisations, co-operatives and mutuals, social enterprises, trade unions and (of particular relevance to this research) Social Landlords (HM Government, 2010). The third sector, in reference to the public sector and the private sector, is also termed 'the voluntary sector' (although it includes non-voluntary organisations), 'the community sector' and the 'non-profit sector' (Halfpenny and Reid, 2002). The third sector aims to deliver mutual benefits for people and society and is frequently defined as non-governmental or not for profit (HM Government, 2010). The third sector, at all levels, has particular skills (such as community engagement, energy conservation, Fuel Poverty initiatives, and green building skills) that enable it to influence attitudes and behaviour, and to increase the demand for action by government (HM Government, 2010). It plays a critical role in increasing understanding and action at an individual and community level and in increasing the support for action at both local and national levels (Ministerial Third Sector Task Force on Climate Change, 2009).

As third sector organisations, approximately 1900 Registered Social Landlords across the UK (these include Housing Associations, Arms-Length Management Organisations (ALMOs), Local Authorities, Trusts and Cooperatives) (Tenant

Services Authority, 2010) have a key role to play in the extensive programme of work to retrofit existing housing, as they are responsible for 3.8 million homes (DECC, 2009a).

The previous Labour Government's strategy set out in 'Shaping Our Future' includes a commitment by Government to work jointly with the third sector to encourage people to reduce energy consumption as part of meeting CO_2 emissions targets and to assist in the national challenge to make homes more energy efficient (DECC, 2010c). Until 2010 the Cabinet Office of the UK Government referred to the term 'Third Sector' and had an 'Office of the Third Sector'. The Coalition Government renamed the department the 'Office for Civil Society'. The term 'third sector' has now been replaced in Government usage by the terms, 'voluntary sector', 'Civil Society' or more usually the term 'Big Society', which was devised by political advisers and developed into a central policy programme (Alcock, 2010).

The Coalition policy programme of 'Big Society' does not however appear to diverge greatly from the path that the Government set out in *'Shaping Our Future'* (HM Government, 2010). Policy still focuses on the importance of the third sector for successful action on climate change (Cabinet Office, 2010).

2.3   Fuel Poverty Policy

Efforts to improve energy efficiency and reduce carbon emissions often work alongside other strategies to improve the quality of life of residents, such as reducing Fuel Poverty. A household is said to be in Fuel Poverty if it needs to spend more than 10 per cent of its income to maintain an adequate level of warmth (usually defined as 21°C in the main living area, and 18 °C for other occupied rooms) (National Statistics, 2011). The emphasis is on heating the home, however fuel costs in the definition of Fuel Poverty also include spending on water heating, lights, appliance usage and cooking costs (National Statistics, 2011). Living in cold homes can impact on people's health and affect their quality of life. The elderly, children, and those with a disability or long-term illness are especially vulnerable (DECC, 2009c).

In 2009, the number of fuel poor households in the UK was estimated at approximately 5.5 million, a rise of 1 million compared to 2008 and representing 21 per cent of all UK households (National Statistics, 2011). The figure is now likely to

be higher due to significant price increases in gas and electricity in 2011 (NEA, 2011). Vulnerable households have been defined for the purposes of the Decent Homes Standard as those in receipt of at least one of the principle means tested or disability related benefits, for example, income support, housing benefit, council tax benefit or disabled persons tax credit. Figure 1, below shows the number of UK households in Fuel Poverty from 1996 to 2009(note that there is no data for years 1997, 1999 and 2000).

Figure 1: Total Fuel Poverty in the UK and Vulnerable Households, 1996-2009
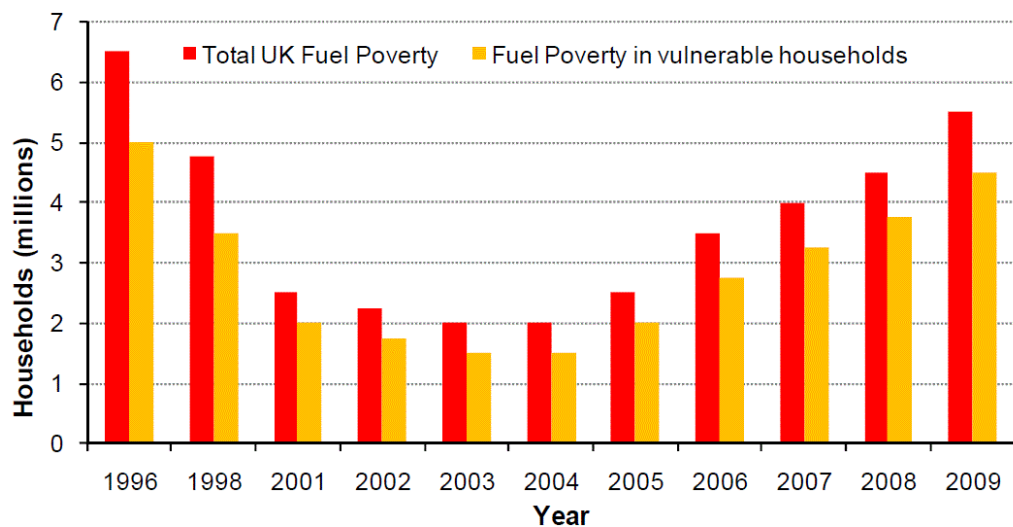
(Source: National Statistics, 2011, p. 9)

Fuel Poverty, in 2009, was at higher levels than in 1998, mainly because of rises in fuel bills. The reduction in Fuel Poverty between 1996 and 2003 was predominantly due to a combination of reduced prices and rising incomes, but the installation of energy efficiency measures in homes also helped to reduce energy consumption and thus reduce energy bills (National Statistics, 2011). However, between 2004 and 2009, energy prices increased, with domestic gas prices rising by 122 per cent and electricity prices rising by 75 per cent, over the same period. This contributed to the increase in Fuel Poverty seen over this period. For some households, the increasing energy prices have been partially offset by rising incomes and improvements in household energy efficiency. Nevertheless, the overall effect of price rises since 2004 has far outweighed the impact of energy efficiency and increasing incomes (National Statistics, 2011).

In addition to setting a number of climate change and carbon emissions reduction targets, the Government has a commitment to eradicate Fuel Poverty. The main factors which have an effect on Fuel Poverty are household energy efficiency, energy prices and household incomes. The UK Fuel Poverty Strategy attempts to address Fuel Poverty by focusing on these three areas (DECC, 2009c).

Energy efficiency through measures such as improved insulation and heating systems aims to reduce fuel bills and remove households from Fuel Poverty. The Government has delivered measures such as this through the Warm Front Scheme in England. Devolved administrations are also operating similar schemes (DECC, 2009c). The Green Deal and the ECO will run in parallel and are intended to support the UK Fuel Poverty Strategy, with the ECO focusing particularly on the needs of the most vulnerable and on those in hard to treat homes, who need additional support (DECC, 2011k). The ECO will represent the only measures-based Fuel Poverty programme in England when the Warm Front Scheme ends in March 2013. As with the programmes it will replace such as the CERT and CESP, which end December 2012), the ECO will be funded through levies on domestic energy bills. FITs will also be funded through additional levy on consumer bills, however the RHI will be funded through HM Treasury (NEA and JRF, 2011).

Energy price increases have been the largest factors in the rise of Fuel Poverty since 2004 (National Statistics, 2011). Following public concern about energy prices, the regulator Ofgem carried out a retail markets probe in 2008. Ofgem subsequently developed a number of processes aiming to address problems identified by the probe. These remedies include license conditions to prevent unfair discrimination between customer groups, and improvements in customer protection relating to direct selling. Suppliers also have a voluntary agreement on programmes of social assistance for vulnerable customers. Ofgem reported that in the first year of the agreement, 2008/09, suppliers have collectively spent £157million against a target of £100million and that over one million customer accounts were benefiting from a social tariff (DECC, 2009c).

Low income is a contributor to Fuel Poverty, because it impacts on the ability of a household to pay for fuel bills. The economic recession has increased unemployment in the UK and thus has had an impact on the number of households in fuel poverty. The Government has however attempted to support household

incomes with Winter Fuel Payments and Cold Weather Payments in 2008 (DECC, 2009c).

2.3.1 Potential Energy Policy Implications for Fuel Poverty

There is concern from Fuel Poverty charities that carbon reduction programmes will have a potentially negative impact on low-income and vulnerable consumers due to the way they are funded. DECC estimates that existing levies supporting a range of Government policies to address climate change, enhance energy security, secure investment in new infrastructure, and tackle Fuel Poverty through targeted energy efficiency measures currently add £88 to the average domestic energy bill. Forecasts estimate these charges will increase to £160 by 2020 (DECC, 2010d).

In a recent report '*Time to Reconsider UK energy and Fuel Poverty Policies'* (NEA and JRF, 2011), the NEA and JRF have raised concerns regarding policy developments to address climate change. The report questions if the Government's policy approach towards reducing carbon emissions can co-exist with a socially just approach that seeks to protect low-income consumers from higher energy bills. Their concerns not only focus on the regressive impact of uniform levies on consumer bills, but also on disparity between social and environmental objectives. The report also argues that the inequitable nature of the regressive funding mechanism is compounded by lack of equal access to the potential benefits delivered by policy. The report puts forward the following key conclusions and recommendations, regarding UK Fuel Poverty policy:

- *"Where tensions between social and environmental objectives are allowed to develop there is an understandable risk that people will prioritise their immediate living environment over what may appear to be a remote and hypothetical global issue...*

- *...The end of Exchequer-funded, grant-aided energy efficiency programmes implies a reduced commitment by government to the eradication of fuel poverty.*

- *Funding energy efficiency programmes through flat-rate levies on energy bills is regressive and unfairly penalises financially disadvantaged households. The most progressive and equitable means of funding...the UK Fuel Poverty Strategy, is through general taxation.*

- *Where responsibility for domestic energy efficiency interventions is delegated to energy suppliers, the Government must adopt a highly prescriptive approach to*

> *ensure that resulting programmes maximise the benefits to fuel-poor households.*
>
> - *All aspects of energy-related policy development should contain an assessment of the implications for fuel-poor households and proposals on how any potentially harmful consequences are to be addressed and resolved.*
>
> - *The forthcoming ECO should exclusively focus on vulnerable fuel-poor households...*
>
> - *Future energy policy can only be seen to be contributing to a socially just transition to a low carbon society if adequate resources are made available to provide fuel-poor households with no-cost interventions that reduce their energy demand, while ensuring that they can heat their home to a satisfactory standard at an affordable cost. By ensuring that low-income and vulnerable households' risk of fuel poverty is minimised, and their access to energy efficiency interventions is maximised, it then becomes possible to contemplate the introduction of the 'polluter pays' principle in the form of a consumption-based levy..."* (NEA and JRF, 2011, p. 18)

The above conclusions and recommendations indicate that the social dimensions of the UK strategy for low carbon housing do not appear to be receiving sufficient attention. Much as occupants' behaviour related to energy use can impact on the energy saving potential of the Green Deal, the approach to low carbon retrofit could potentially impact on the efforts to reduce Fuel Poverty because of the way it is funded.

2.4   Behaviour Change Policy

Governments can deploy a variety of different types of policy intervention to change the behaviour of the population. These range from providing information or undertaking campaigns of persuasion that promote certain behaviour, to taxation and legislation. Traditionally UK climate change policies focus on voluntary reduction of energy use by individuals, encouraged through communication of information and economic incentives and subsidies (DETR, 2000; HM Government, 2006), and thus only pay limited attention to behaviour change. The underlying rational of these policies and initiatives are that information and changing attitudes may result in behavioural change. While public awareness and concern about climate change has increased in the UK recently (Poortinga and Pidgeon, 2003; GlobeScan, 2006; Lorenzoni et al., 2007), an individual's awareness and concern for the issues does not always translate into more efficient energy use in the home (Bord et al., 2000; Lorenzoni et al., 2007).

2.4.1 Frameworks for Behaviour Change

The previous Labour Government developed a '*Framework for pro-Environmental Behaviours'* (DEFRA, 2008), which focused on environmental attitudes and behaviours in relation to carbon emissions. The framework described in the report identified behavioural goals and set out an approach to changing behaviour through DEFRA's informational campaigns, such as, Act on CO_2. The framework argued that there was a mandate for Government to take action to help 'green' those lifestyles. Figure 2, below, shows a diagram of the then proposed, 'roadmap' for environmental behaviour change.

Figure 2: DEFRA roadmap for environmental behaviours in 2008
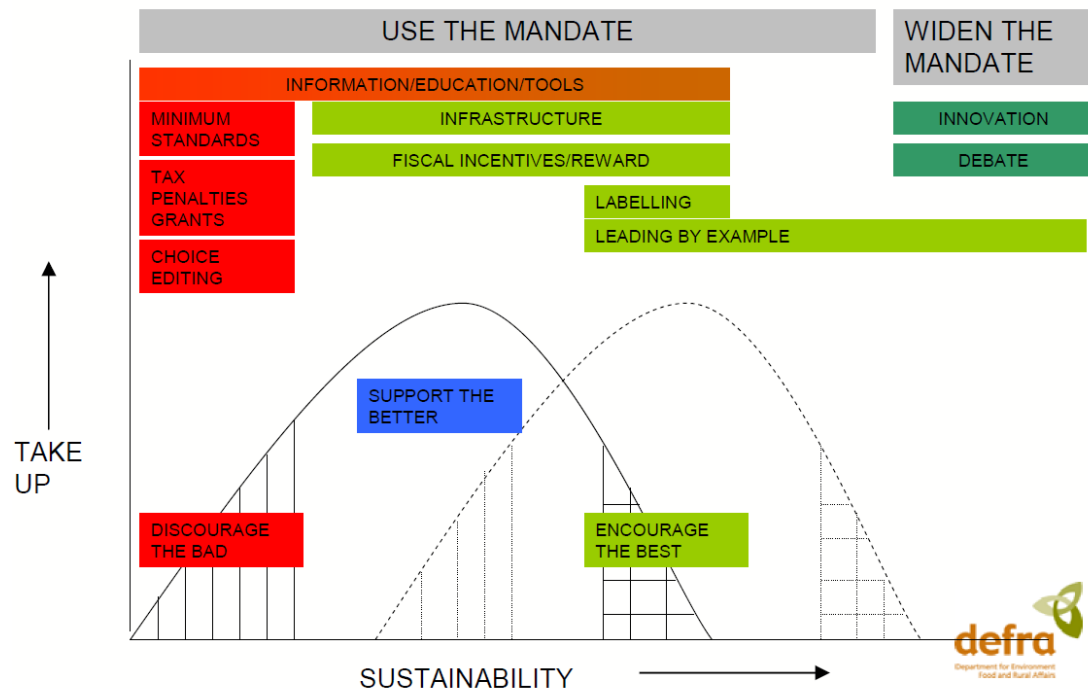
(DEFRA, 2008, p. 20)

Building on this 2008 framework, DEFRA's 'Centre of Expertise on Influencing Behaviour' has set out a '*Framework for Sustainable Lifestyles'* (DEFRA, 2011) as a tool to support DEFRA and external organisations to develop effective approaches to influence behaviour. The framework is aimed at: sharing evidence, learning, and best practice in influencing behaviour; the Centre's engagement, advice and capability building across DEFRA and wider organisations; contributing to the approach taken by other organisations (i.e. the behaviours they focus on) and the key motivations and barriers to action; the types of approaches more likely to be effective (DEFRA, 2011). It is interesting to note the change in terminology in the

2008 and 2011 frameworks –'behaviour change' is frequently mentioned in the 2008 framework, whereas the latter framework, refers to 'influencing behaviour', even emphasising the difference in the '*Framework for Sustainable Lifestyles*' (DEFRA, 2011):

> *"…'**Behaviour change' vs. influencing behaviour –** 'behaviour change' can imply top-down approaches. We talk about interventions to 'influence behaviour' to recognise that sometimes we are encouraging people to maintain behaviours; to undertake current behaviours more frequently; other times to adopt new behaviours; and sometime to adapt current behaviours"*

> (p. 9, bold is their emphasis)

The '*Framework for Sustainable Lifestyles*' (DEFRA, 2011) identified the key set of 'Headline Behaviours' i.e. groups of behaviours that represent nine priority areas and, 'Key Behaviours' which highlight the most important behaviours with the headline groups. Figure 3, shows the 'Headline Behaviours' related to energy use, which are of particular relevance to this PhD research.

Figure 3: Headline and Key Behaviours Related to Energy Use

Headline Behaviours	Key Behaviours	Sub-Behaviours
Eco-improving your home (retrofitting)	• Insulating your home • Upgrading heating & hot water systems • Fitting & using water saving devices • Generating own energy by installing renewable	Installing loft insulation; Topping up loft insulation; Installing solid wall insulation; Installing double glazing; Upgrading boiler; Upgrading to low flush toilet; Fitting water efficient shower head; Fixing dripping taps; Wind; Solar/electric; Solar/water; micro-CHP; Ground and air source heat pumps.
Using energy & water wisely	• Managing Temperature • Washing & drying laundry using minimum energy & water	Fitting & using temperature controls; Line drying laundry; using right amount of detergent; Switching to green energy tariff

(Adapted from: DEFRA, 2011)

The Government appears to be focusing on behaviours which involve the installation of technologies or the retrofitting of homes. The predominant approach is to influence behaviours related to the consumption of particular products, technologies

or services in order to improve domestic energy efficiency. Behaviours related to energy use are only briefly mentioned within the framework, with the focus on influencing three sub behaviours: using temperature controls; line drying laundry and; using the right amount of detergent (DEFRA, 2011).

The previous Labour Government's '*Framework for pro-Environmental Behaviours'* (2008) proposed a 'roadmap' for behaviour change (see figure 2), to 'Discourage the bad' (through: information and education; tax; penalties; choice editing) and 'Encourage the best' (through: infrastructure; fiscal incentives/reward; labelling, and; leading by example). As discussed further below, this approach appears to have shifted under the Coalition Government, perhaps in an attempt to avoid more overt interventions, which contributed to the labelling of the previous Labour Government as a 'nanny state' (Bowden, 2011).

2.4.2 The Non-Regulatory, Non-Fiscal Approach or 'Nudge'

The policy literature suggests that the current Government is taking a more subtle approach to behaviour change policy in the vein of the 'Nudge' concept (Science and Technology Select Committee, 2011). Thaler and Sunstein's book, '*Nudge: Improving Decisions about Health Wealth and Happiness'* (Thaler and Sunstein, 2008) advocates a range of non-regulatory interventions that seek to influence behaviour by altering the context or environment in which people choose, and seek to influence behaviour in ways which people often do not notice. Thaler and Sunstein (2008) discuss the parallels between 'Choice Architecture' and 'Traditional Architecture'. 'Choice Architecture' as outlined by Thaler and Sunstein (2008) describes the way in which decisions are influenced by how the choices are presented, in order to influence the outcome. It links to 'Libertarian Paternalism', i.e. the idea that it is both possible and legitimate for private and public institutions to affect behaviour while also respecting freedom of choice (Thaler and Sunstein, 2003).

This 'Choice Architecture' or 'Nudge' approach differs from more traditional government attempts to change behaviour, which have either used regulatory interventions or relied on overt persuasion (Science and Technology Select Committee, 2011). Table 4 below shows a range of types of policies that affect the way people behave, along with examples of types of intervention. The current Government is embracing 'Choice Architecture' or 'Nudge' which is towards the right

of table 4. 'Nudge' interventions can be considered as a subset of non-regulatory interventions, because 'Nudges' prompt choices without getting people to consider their options consciously, and therefore do not include openly persuasive information. Also 'Nudges', although not considered to be regulatory, can in fact utilise regulatory policy in order to 'Nudge' individuals or to create choice (Science and Technology Select Committee, 2011).

The Science and Technology Select Committee's report, *'Behaviour Change'* (2011) was the culmination of a year-long investigation into the way the Government tries to influence people's behaviour using behaviour change interventions. The report concludes that 'Nudges' used in isolation will often not be effective in changing the behaviour of the population. Instead, a whole range of measures, including some regulatory measures, will be needed to change behaviour to address society's biggest problems. Table 4 below, shows a range of these policies which affect behaviour and associated examples of policy interventions.

Table 4: Polices that affect behaviour with examples of policy interventions

Interventions category	Regulation of the individual		Fiscal measures directed at the individual		Non-regulatory and non-fiscal measures with relation to the individual						
							Choice Architecture ("Nudges")				
					Guide and enable choice						
	Eliminate choice	Restrict choice	Fiscal disincentives	Fiscal incentives	Non-fiscal incentives and disincentives	Persuasion	Provision of information	Changes to physical environment	Changes to the default policy	Use of social norms and salience
Examples of policy interventions	Prohibiting goods or services e.g. banning certain drugs	Restricting the options available to individuals e.g. outlawing smoking in public places	Fiscal policies to make behaviours more costly e.g. taxation on cigarettes or congestion charging in towns and cities	Fiscal policies to make behaviours financially beneficial e.g. tax breaks on the purchase of bicycles or paying individuals to recycle	Policies which reward or penalise certain behaviours e.g. time off work to volunteer	Persuading individuals using argument e.g. GPs persuading people to drink less, counselling services or marketing campaigns	Providing information in e.g. leaflets showing the carbon usage of household appliances *Regulation to require businesses to use front of pack nutritional labelling, or restaurants to provide calorific information on menus	Altering the environment e.g. traffic calming measures or designing buildings with fewer lifts *Regulation to require businesses to remove confectionery from checkouts, or the restriction of advertising of unhealthy products	Changing the default option e.g. requiring people to opt out of rather than opt in to organ donation or providing salad as the default side dish	Providing information about what others are doing e.g. information about an individual's energy usage compared to the rest of the street *Regulation to require energy companies to provide information about average usage

Note: * Demonstrates how regulation of businesses might be used to guide the choice of individuals, thus distinguishing it from regulation which restricts or eliminates the choice of individual.

(Source: Science and Technology Select Committee, 2011, p. 10)

2.4.3 Informing Policy through Behaviour Change Research

The *'Behaviour Change '*report by the Science and Technology Select Committee (2011) has surmised that, although much is understood about human behaviour from research, there has been to date relatively little evidence about how this understanding could be applied in practice at population level. Further applied research is needed at a population level, however based on available evidence the report concludes that non-regulatory measures used in isolation, including 'Nudges', are less likely to be effective. The authors highlight the issue that effective policies often use a range of interventions and consider all possible interventions, at the design stage. This is particularly important in the current policy context as evidence received by the Science and Technology Select Committee indicated that the Government's preference for non-regulatory interventions has reduced the scope for regulatory measure consideration with regard to behaviour change.

The '*Behaviour Change'* report (Science and Technology Select Committee, 2011) also recommended that the Government should more frequently utilise available evidence in order to inform behaviour change policy, as there was evidence that some previous behaviour change policies such as, on food labelling and alcohol pricing, had not taken into account all the available evidence. The report also suggested that more work should to be done, to improve the evaluation of interventions, in order to improve best practice, and to build a body of research that can inform effective policies targeting population-level behaviour change.

2.4.4 Behaviour Change and Energy Use

The Government's Behavioural Insights Team has recently published a report titled '*Behaviour Change and Energy Use'* (Cabinet Office, 2011). The report presents research, using a range of trials to test different ways of applying behavioural insights to overcome barriers to being more energy efficient and reduce carbon emissions. It aims to inform Government policy on energy efficiency and carbon reduction in order to be as effective as possible in motivating behavioural change. The report covers three key areas:

▪ Helping people to green their homes and be more energy efficient
  - Encouraging uptake of the Green Deal (through economic incentives)
  - Increasing the uptake of renewable energy generation (though economic incentives, such as the Renewable Heat Incentive)

- Helping people to reduce energy consumption through better information
  - Comparative energy consumption (feedback on how a person's household energy consumption compares with another)
  - Reforming Energy Performance Certificates (to make information clearer and more salient for those considering renting or buying a home)

- Government and businesses leading by example
  - Reducing Government emissions (Government has reduced emissions and is leading by example by using social norms to encourage behaviour change)
  - Working with others to achieve change (invites other organisations to make public commitments to reduce energy use and emissions by setting targets through the new Responsibility Deal).

(Cabinet Office, 2011)

The approach outlined in the report is mainly focused on changing behaviour through economic incentives and the provision of clearer information. It is interesting to note that the Government is not encouraging behaviour change as such, but encouraging the consumption of energy efficient technologies to be retrofitted to homes, which may lead to energy savings and carbon reduction. This concurs with the Government's general approach to behaviour change policy, which encourages behaviour change through 'Choice Architecture' or 'Nudge' (see discussion above). However, behaviour change in terms of energy use in the home is not prominent in policy, for this does not work in line with the Government's 'Libertarian Paternalism' approach to respect freedom of choice. Instead the focus is on 'Nudging' people, by providing financial incentives (made possible through regulatory changes), to encourage householders to install energy efficient and low carbon technologies in their homes. It is likely that social-norms will also encourage further 'Nudge' when people are reminded through the media of any financial rewards of taking up the scheme compared to peers who face increasing energy prices, which are in part caused by the regulatory changes associated with the 'Nudge' policy.

'Nudge' initiatives such as, the Green Deal, Feed-In Tariff and the Renewable Heat Incentive are key components in the UK Strategy for Low Carbon Housing to mobilise the retrofit of approximately 600,000 homes per year to meet carbon emissions reduction targets (EST, 2010a). Using 'Nudge', Government aims to mobilise the UK public to retrofit their own homes using their own personal capital by

taking out a loan, made possible through a new type of financial agreement (DECC, 2010b) enabled by regulatory reform (Energy Act, 2011). Average energy bills across the UK will be increased due to the regulatory reform (NEA and JRF, 2011) alongside potential price increases due to market forces and thus encourage a financial choice in the public to retrofit homes through Green Deal, in order to reduce energy bills. The proposal is that the UK public will mobilise the capital and supply chain to make national retrofit possible, by being 'Nudged' to make a consumption choice, but the public at large will not realise they have been encouraged to change their behaviour.

In relation to retrofit, the Government does not appear to be focusing on domestic energy use behaviour change as such, but on changing purchasing behaviour towards the uptake of energy efficient technologies. Attention is given to the provision of information such as, comparative energy use or Energy Performance Certificates (EPCs), but again the focus is on financial implications of purchasing behaviour towards an energy service, home rental or purchase.

There is a danger that focusing on financial 'Nudges' to mobilise energy efficient technologies through the public purse, while paying limited attention to domestic behaviour related to energy use, may not deliver intended energy and carbon savings. Energy efficient technologies can be retrofitted to existing homes to assist energy efficiency, but overall it is the occupants of homes and their behaviours related to energy use, which determine energy consumption from homes over the coming decades. If the energy related behaviour of occupants is overlooked, the significant mobilisation to retrofit UK housing stock though policy mechanisms such as Green Deal, may not achieve the energy savings or carbon reductions it set out to achieve. If so, the public will literally pay for this mistake.

2.5   Overview of Policy Landscape

2.5.1 Retrofit Policy

Over the last decade a range of Government policies and initiatives have been introduced, in an attempt to address the challenge of reducing carbon emissions from housing and tackling fuel poverty. For example, the Decent Homes Standard, aiming to deliver a reasonable degree of thermal comfort through effective insulation and heating. The social housing sector has made considerable progress and by

2009 86% of homes in the sector were considered to be decent (National Audit Office, 2010). The Warm Front Scheme has delivered measures to 2.3 million heating and insulation improvements to households on certain income-related benefits living in properties that are poorly insulated and/or do not have a working central heating system. Also, the previous Government's 'Warm Homes, Greener Homes: A Strategy for Household Energy Management' outlined ambitious targets (backed by schemes such as the FiT and RHI) to deliver huge numbers of energy efficiency measures and create tens of thousands of jobs in a new industry of energy efficiency (DECC, 2010c).

In essence the approach prior to the 2010 election has been to retrofit energy efficient or low carbon technologies either by funding their installation through Government funded schemes such as the Decent Homes Standard, Warm Front Scheme, CERT and CESP, or though Government provided financial incentives to make their installation more attractive, such as the Feed-In Tariff. This has resulted in significant retrofit programmes and an improvement in the standard of homes, especially in the social housing sector. Funding for these programmes has been delivered through Government grant schemes for improving energy efficiency. It could be argued that this approach has been predominately state managed and represents a social welfare retrofit approach.

More recently, since the 2010 election of the Coalition Government, the principle of delivering energy efficient retrofits to reduce carbon emissions and reduce fuel poverty has not changed. However, the shift in political power appears to have created a shift in the mechanisms to fund retrofit application.

The post-2010 Government strategy for reducing carbon emissions and fuel poverty is similar in many respects to the previous Labour Governments approach, whereby the retrofit of energy efficient and low carbon technologies to existing homes is intended to significantly reduce energy use and carbon emissions from UK housing. Indeed, even flagship policies such as the Green Deal and ECO, announced by the Government immediately after the 2010 general election had their foundations in previous government policy such as the Labour Government's Pay As You Save (PAYS) programme. On the surface they are very similar schemes, however, unlike PAYS which would utilise Government funding Green Deal is effectively a loan which needs to be paid back (through energy bills) over a set period by any member of the public living in a home which has been subject to the Green Deal scheme.

Essentially the capital investment for the retrofit of all UK homes will be mobilised by encouraging the public to take out loans against their homes instead of being provided by state grants. One of the defining principles of Green Deal is that it will create economic growth and jobs, and it appears that the capital being mobilised by such loans will be used to generate business and growth through the range of organisations now involved (or created) due to the Green Deal scheme, such as Green Deal Providers, Green Deal Assessors, Certification Bodies and Green Deal Finance Companies. In this sense, Green Deal is shifting the responsibility for delivering energy efficiency programmes away from the state and towards private industry. The market has essentially been put forward as a core means of delivering economic growth, reducing carbon dioxide emissions and tackling fuel poverty.

It could be argued that the post-2010 retrofit policy context has shifted from a state managed social welfare approach towards a private finance and private industry approach. A likely explanation of this change in approach after the 2010 election is due to the change in political power and associated political stances of the previous Labour Government and the subsequent, Conservative-dominated Coalition Goverment. Nevertheless, the influence of the economic recession and the UK's budget deficit on political strategy cannot be ignored, and this is likely to have created further urgency for policies which not only proritise economic growth, but also bring a private sector focus.

The Energy Company Obligation (ECO) which will support cases when the 'Golden Rule' of the Green Deal will not apply. ECO will supersede existing obligations to reduce carbon emissions (CERT and CESP) which expire at the end of 2012. ECO is particularly important for the social housing sector as it currently unlikely that the Green Deal will be applicable or workable for socially rented properties and previously utilised funding from CERT and CESP will cease in 2012. ECO has been criticised by NEA and JRF (2011) for being inequitable due its funding being sourced through flat-rate levies on all household energy bills. This also reflects the general shift in Government policy towards the public paying for energy efficiency measures instead of through grant-aided efficiency programmes.

These changes in the policy context have important implications for the social housing sector. Green Deal and ECO will soon be the only energy efficiency retrofit programmes available. The end of Government grant-aided energy efficiency programmes leaves minimal avenues for social housing to fund the delivery of

retrofit programmes and address the needs of fuel poor tenants which make up a significant proportion of households. Delivering Green Deal in social housing is likely to be problematic because RSLs own the housing stock and tenants are liable for the bills, therefore tenants will be paying for improvements on a home that they do not own and investing their money in the RSLs housing stock. ECO could have been an avenue to deliver retrofit programmes to target vulnerable fuel-poor households, however this has been delivered and the scheme is provided through inequitable flat-rate levies on energy bills will unfairly penalise financially disadvantaged households.

2.5.2 Behaviour Change Policy

As discussed above the policy focus is on the improvement of building performance through technology application, however the influence of occupant energy use behaviour on the effectiveness of such technology application has not been mentioned in the policy literature. Where the policy literature does focus on environmental and energy related behaviour it pays relatively little attention to acts of behaviour relating to energy use, focusing more on behaviours which involve the consumption and/or installation of particular products or technologies which aim to improve energy efficiency. This is concerning because other research has indicated that occupant behaviour can have a significant influence on the energy use in buildings (Gill et al., 2010; Stevenson and Leaman, 2010). Therefore, there is a risk that the policy of retrofitting homes may not achieve potential energy efficiency or fuel poverty and carbon reduction targets due to the impact of occupant behaviour.

In terms of the behaviour change policy context there again been a shift in approach due to the change in government in the 2010 elections. The previous Labour Government had developed '*Framework for pro-Environmental Behaviours'* (DEFRA, 2008), which focused on environmental attitudes and behaviours in relation to carbon emissions. The framework identified behavioural goals and set out an approach to changing behaviour through DEFRA's informational campaigns, such as, Act on CO_2. The framework argued that there was a mandate for Government to take action to help 'green' those lifestyles. Interestingly, after the 2010 elections DEFRA's updated *'Framework for Sustainable Lifestyles'* (2011) indicate a shift in terminology and approach moving away from the idea of 'changing behaviour' and towards 'influencing behaviour'. This may have been a way of distancing the Coalition Government from the previous Labour Government's more

overt policy interventions, which led to the labelling of the revious Labour Government as a 'nanny state' (Bowden, 2011). The policy literature suggests that the current Government is attempting to take a more subtle approach to behaviour change policy in the vein of the 'Nudge' concept or Choice Architecture (Science and Technology Select Committee, 2011). This links to the idea of 'Libertarian Paternalism', i.e. that it is both possible and legitimate for private and public institutions to affect behaviour while also respecting freedom of choice. However, as discussed earlier (see 2.4.4) the policy literature indicates that 'Nudge' is less about encouraging behaviour change in terms of domestic energy use and more about encouraging the public to purchase energy efficient technologies. It is also worth questioning if this is actually about 'choice' or simply another version of 'stick' (increasing energy bills due to levies) and 'carrot' (opportunity to reduce energy bills through a Green Deal retrofit).

2.6   Conclusions

Retrofit programmes for installing energy efficient technologies in social housing, play an important part in the UK carbon reduction strategy (DECC, 2009a). Over recent years a suite of policies and Government initiatives have been introduced in an attempt to address the challenge of reducing the energy consumption and carbon emissions attributed to existing housing in the UK. Current and proposed policies predominately focus on the retrofit of energy efficient or low carbon technologies either by providing funding for their installation (e.g. Decent Homes Standard, Warm Front Scheme, CESP) or by providing financial incentives to make their installation more attractive (e.g. Green Deal, Feed-In Tariff, Renewable Heat Incentive).

The technical approaches to energy efficiency and carbon reduction that have been explored in this chapter do pay some attention to home occupiers' behaviour related to energy use, by making use of energy feedback as an opportunity to engage with the householder on energy performance and using information sources that can influence behaviour change. However, the potential influence of occupant behaviour related to energy use on associated retrofit as a result of these policies is not acknowledged. In addition, DEFRA's '*Framework for Sustainable Lifestyles'* (2011), which does focus on influencing behaviour to be more sustainable, has very little mention of acts of behaviour relating to energy use (using temperature controls; line drying laundry; using right amount of detergent) focusing in the main, on behaviours which involve the consumption of particular products, technologies. The main

attention given to behaviour related to energy use is in the 'Nudge' or 'Choice Architecture' approaches to encourage the consumption of attractive financial deals, which involve the purchase and installation of retrofit technology. In accordance with its attraction to 'Libertarian Paternalism', the current coalition Government, unlike the previous Labour Government, does not seem interested in 'behaviour change', but is more interest in 'influencing behaviour', and if possible, doing so without the public even noticing.

Fuel Poverty a related issue to retrofit and behaviour related to energy use, is still a major problem in the UK despite efforts to improve the situation through retrofit installations, with a significant proportion of households in Fuel Poverty, residing in social housing. Fuel Poverty, in 2009, was at higher levels than in 1998, mainly because of rises in fuel bills (National Statistics, 2011). Policy intends to reduce Fuel Poverty through energy efficiency and carbon reduction strategies for UK housing. However policies such as Green Deal are not suitable for a majority of fuel poor households and the substitute ECO, targeted for the fuel poor, has inequitable provisions which do not target the fuel poor first. Additionally, tensions exist between social objectives of Fuel Poverty and environmental objectives of CO_2 emissions, principally due to the funding mechanisms to pay for the mobilisation of energy efficient and low carbon retrofit. It is levied in an inequitable way by raising fuel bills, for everyone, regardless of the amount of energy they use and associated CO_2 emissions they produce, thus it does not reflect the 'Polluter Pays' principle.

Thus far, significant investment has already been made towards retrofitting existing homes. Through emerging policies such as the Green Deal a significant mobilisation is anticipated in the energy efficient retrofit of UK housing stock. The huge capital required for investment is mostly being delivered by the public by taking out loans from energy companies and levies on public bills. However, the policy literature, shows that the Government is not addressing occupant behaviour related to energy use in order to mitigate the potential threat to retrofit energy efficiency or carbon reduction goals, due to unanticipated behaviours of the nation's domestic energy users.

As will be discussed further in Chapter 3, behaviour related to energy use can have a significant impact on the energy efficiency and carbon reduction potential of retrofits. For example, comfort 'takeback' can reduce potential energy savings by 20-30%, and that alone could potentially leave the UK Strategy for Low Carbon

Housing considerably short of the 80% carbon emissions reductions targets set out in the Climate Change Act (2008).

By evaluating the impacts of a social housing retrofit project on behaviour related to energy use, this PhD research aims to improve understanding of behaviour related to energy use in this setting. By highlighting some of these occupant behaviour aspects it is the intention that they are considered as part of the equation in delivering future retrofit programmes. Thus, this knowledge will hopefully contribute to the design and implementation of retrofit programmes in order to improve energy efficiency and carbon reduction potential and support the UK strategy for low carbon housing.

Qualitative research is particularly useful to policy makers and planners by providing descriptive information and understanding of the context in which policies will be implemented (Murphy et al, 1998). This PhD research into behaviour related to energy use in the context of housing retrofits can inform policy makers and retrofit programme implementers and thus assist in the development of retrofit programmes which incorporate this critical component.

3. Literature Review

3.1   Introduction

As mentioned earlier (in section 1.1.2), occupant behaviour is a key factor which influences energy consumption and carbon emissions from buildings and homes (Smith and Pett, 2005; Janda, 2009; Gill et al., 2010; Stevenson and Leaman, 2010; Morley and Hazas, 2011). Occupant behaviours may also impact on the potential effectiveness (i.e. energy saving potential) of energy efficiency and low carbon retrofits. The purpose of this research was to further understand how behaviours related to energy use are affected by an energy efficiency retrofit project and identify some of the barriers to retrofit effectiveness. This chapter explores the areas of literature and key debates which are relevant to this research, first by exploring broader theories explaining behaviour and then by focusing on specific literature associated with household behaviour related to energy use.

Much of the literature attempting to explain human action or activities is from the discipline of Psychology and relates to 'Psychological Theories of Behaviour' (3.2). Other paradigms such as sociology also contain related literatures, but Psychology is particularly dominant in understanding (and applying practical interventions to change) human behaviour, including behaviour related to energy use. Thus, Psychological theories of behaviour and how these apply more specifically to the energy use behaviour of household occupants are more prominent in this literature

review. However, 'Practice Theory' (3.3), from the paradigm of Sociology is also given attention because work in this area also attempts to explain human action or activities related to consumption, including energy use. In particular, Practice Theory is relevant because it provides a contrasting perspective compared to Psychological theories of behaviour, observing from the societal level rather than the individual level. Both the perspectives of Psychological theories of behaviours and Practice Theory were considered relevant for the literature review, although their contrasting approaches and background are fully acknowledged (3.4). Together literature from both paradigms provide two viewpoints on behaviour: an insight into the nature of individual behaviour (Psychological theories of behaviour), and; a consideration of how the framework and structure of society (including aspects such as technology) interacts with the individual's practices (Practice Theory).

The perspective of Practice Theory is generally sidelined from policy circles exploring the means of changing consumption behaviours related to sustainability, in favour of the dominant psychological perspectives. However, in the last few years Practice Theory appears to have received more attention within interdisciplinary literature reviews on sustainable behaviour. It was considered important to include Practice Theory in this literature review as it not only provides another perspective of behaviour (as practices), but the theory itself has strong implications for policy on sustainability.

After these two broad theory approaches have been discussed literature is drawn from both perspectives where appropriate, to then focus more specifically on 'Household Behaviour Related to Energy Use' (3.5). This section discusses the influence of household occupants on energy consumption and factors which influence household occupant behaviour related to energy use. Attention is given to Interventions to change energy use behaviour before conclusions are drawn on the key literatures.

3.2   Psychological Theories of Behaviour

3.2.1 Attitude Theories

While this literature review mainly focuses on behaviour, it is important to consider the literature on attitudes before moving on to discuss the relationship between attitude and behaviour. Attitudes are hypothetical constructs attached to an individual's orientation towards or, evaluation of, an 'attitude object' (i.e., thing, idea, person, group, action, self, etc). Typically, the literature understands attitudes based on the ABC model, comprising of three components; cognition (knowledge and beliefs), affect (emotional response) and behaviour (past and current behavioural response). Attitudes form as a result of direct experience with the object or through second-hand (mediated) information about it, the former tending to result in stronger and more consistent attitudes than the latter (Fazio and Zanna, 1981; Kraus, 1995; Glasman and Albarracin, 2006). Attitudes can be said to have an evaluative aspect and a particular intensity and direction; that is, people may hold a strong or weak opinion, which may be positive or negative (Eagly and Chaiken, 1993). It is also possible to be ambivalent about an attitudinal object, and thus hold both positive and negative attitudes. Attitude strength may be determined by an array of factors, such as involvement, ambivalence, certainty, confidence, importance, emotional intensity and underlying values (e.g. Stern et al., 1993; Maio et al., 2001; Verplanken and Holland, 2002).

Within an individual's attitudes, there are differences or even contradictions between 'explicit attitudes' (attitudes that individuals are aware of and believe they have) and 'implicit attitudes' (attitudes that individuals may not be aware of or misjudge due to not recalling or inaccurately recalling previous experience which may mediate attitude) (Greenwald and Banaji, 1995). Attitude measurement tends to operate by direct extraction of communication of support or opposition (e.g. via a questionnaire), but may also be inferred from more subtle reactions to the attitudinal object (Smith and Mackie, 2007). Importantly, there may be a difference (or even contradiction) between communicated attitudes (explicit attitudes) and more subtle reactions (implicit attitudes), because of particular biases in the way people report their views, such as social desirability (i.e. saying what they think they should say or is the 'right answer' (Spence, 2005)) .Implicit attitudes can often explain more variance in behaviour than explicit attitudes, which suggests that behaviour is frequently driven by unconscious processes, rather than deliberation (Maio et al., 2007), see section 3.2.4, on Habit for further discussion.

Attitudes (unlike personality traits) are known to be dynamic, influenced by a range of factors, often ambivalent or uncertain, and frequently not predictive of behaviour. Wicker's (1969) review of the available data on attitude-behaviour consistency indicated that the attitude concept's explanatory power was limited, with up to 10% of overt behavioural variance, accounted for by attitudinal data, and concluded that:

> *"it is considerably more likely that attitudes will be unrelated or only slightly related to overt behaviours than attitudes will be closely related to actions"* (p. 65)

Wicker's (1969) influential review along with others (e.g. Deutscher, 1973) led to considerable scepticism of the attitude-behaviour relationship, to the degree where some suggested that it may be appropriate to discard the attitude concept (Wicker, 1971). However, several studies have indicated a substantial relation between attitudes and behaviour, in the context of organ transplants (Goodmonson and Glaudin, 1971), voting (Kelley and Mirer, 1974), and in an energy use study, the necessity of air-conditioning in maintaining home-owners health and comfort (Seligman et al., 1979). Findings such as these led to a more positive outlook on the usefulness of attitudes in predicting behaviour (Schuman and Johnson, 1976; Zanna and Fazio, 1982).

Ultimately it can be said that there is 'sometimes' a relationship between attitudes and behaviours, according to Fazio and Roskos-Ewoldsen (2005). Numerous studies suggest that attitudes do not influence behaviour (see Wicker's, 1969, and; Deutscher's, 1973 reviews), but sometimes attitudes can, and do predict behaviour.

Nevertheless, more recently, the validity, or indeed existence of attitudes has been questioned by Schwarz (2007) who points out that:

> *"Attitudes are hypothetical constructs that psychologists invented to explain phenomena of interest…Like all hypothetical constructs in science, attitudes derive their right to life from their explanatory power and live at the mercy of Ockham's razor"* (p. 638)

Other related conceptual analyses have suggested it is more accurate to think of attitudes as evaluative judgements formed when needed rather than long-term dispositions (Lord and Lepper, 1999; Smith and DecCoster, 2000). Such empirical and theoretical challenges have not impacted on popular theory which considers attitudes as:

> *"...a psychological tendency that is expressed by evaluating a particular entity with some degree of favour or disfavour"*
>
> (Eagly and Chaiken, 1993, p. 1)

Schwarz (2007) argues that this popular conceptualisation, which still exists in more recent texts (see Eagly and Chaiken, 2007), derives it's intuitive appeal because it is compatible with humans' tendency to explain others' behaviour in terms of their dispositions. Schwarz (2007) notes the irony that this tendency is referred to as 'fundamental attribution error' (where dispositional based-explanations are overvalued, as explanations for the observed behaviours (Ross, 1977)), when exhibited by laypersons –but the same explanatory structure is endorsed as a crucial concept to the field, when the disposition is labelled 'attitude'.

It is however important to acknowledge that attitudes have certain instrumental and symbolic functions for individuals, such as helping organise knowledge, inform decisions, express identity and seek connections with others (Maio and Olson, 2000). Furthermore, the concept of attitudes is helpful in understanding how individuals interpret and respond differently to the same information. Pre-existing beliefs and views (i.e. attitudes) have been shown to bias perceptions and guide behaviour: people are more attentive to, and accepting of, attitude-consistent information and tend to ignore or reject dissonant information (Nickerson, 1998). This characteristic of attitudes highlights the incomparable nature of individuals and the diverse effects of communication.

3.2.2 Theories of attitude change

Attitude change has long been a central concern of social psychologists and may occur through communication (i.e. persuasion) as well as other forms of learning. According to the well-established Elaboration Likelihood Model (Petty and Cacioppo, 1986), there are two routes by which an individual may be persuaded: core (systematic) and peripheral (superficial). Petty and Cacioppo (1986) argue that attitudes may be influenced through the peripheral route –i.e., as 'snap judgements' based on heuristics, such as whether the communicator is attractive, expert or familiar; or even through the 'mere exposure effect' (see Zajonc, 1968), of being frequently exposed to the attitudinal object. In other cases, when individuals are sufficiently motivated to engage with an issue, attitudes will be informed through more considered deliberation of the arguments presented (i.e. the core route), and in this case attitudes tend to be more resistant to change than in the case of more

superficial processing (Petty and Cacioppo, 1986). In general, messages that conform to an individual's motivations and level of interest are more persuasive (Smith and Mackie, 2007). The process of attitude change may be sudden ('conversion') or gradual ('book-keeping'), depending on the amount and distribution of inconsistent information encountered (Weber, 1997). Social influence, embedded in social relations and social identification, also plays a role in the process of attitude change (Wood, 2000).

3.2.2.1   Attitude-behaviour relationship and behaviour change

The literature on behaviour change consistently highlights the complexity in both determining and changing behaviour. Action is influenced by multiple conscious and unconscious processes (Jackson, 2005). Consequently, there are numerous models of behaviour and behaviour change, all of which provide some insight into particular actions in particular contexts, but which often have little transferability across behaviours or contexts (Darnton, 2008). Important implications of this complexity are that: individuals' attitudes and actions are not necessarily consistent, see the 'value-action' gap (Blake, 1999; Kollmuss and Agyeman, 2002), a mechanism for explaining why behaviour often does not align with our beliefs. Although research has highlighted the significant correspondence between attitudes and behaviour, attitudes only occasionally guide behaviour, and most commonly this is where attitudes are strong (e.g. important, based on experience and knowledge or certain) and where social and structural conditions support action (Krosnick and Smith, 1994; Stern, 2000). Principally, the key message emphasised in the literature is that attitudes do not necessarily predict behaviours, and thus changing attitudes (for example, through Informational Interventions) do not necessarily lead to behaviour change.

3.2.3 Models and Theories of Behaviour Change

Most relevant to changing energy saving behaviour and this PhD research are the following five models and theories: the 'Rational-Choice Model', and attitude-behaviour models; the 'Theory of Planned Behaviour'; 'Theory of Interpersonal Behaviour'; 'Attitude-Behaviour-Context Model', and; 'The Needs, Opportunity and Ability Model'. The first three models were considered relevant because they are most frequently referred to in the literature in relation to changing consumption behaviour and pro-environmental behaviour. The latter two models, Needs, Opportunity and Ability Model, and Attitude-Behaviour-Context Model, were chosen

because, in addition, they attempt to address structural and environmental factors. This links with this PhD research because it evaluates energy use behaviour in relation to a change in structure or environment due the retrofit project.

In recent years, efforts have been made to apply some of these models to several domains of environmentally relevant behaviours (for an overview see Bamberg & Möser, 2007). Attempts to promote pro-environmental behaviour including energy conservation have been based mainly around the Rational-Choice Model and the Theory of Planned Behaviour from the field of social psychology (Jackson, 2005). Psychological models traditionally inform strategies and interventions to change behaviour and these Informational and Technical Interventions will be discussed in more detail later in the chapter.

Jackson (2005) also identifies two main groups of approaches to understanding human environmental behaviours. One group of approaches, model behaviour as a function of processes and characteristics which are conceived as being internal to the individual –attitudes, values, habits and personal norms. The other group of approaches study behaviour as a function of processes and characteristics external to the individual, such as fiscal and regulatory incentives, and institutional constraints. This is not a complete distinction as the internal formation of attitudes or acknowledgement of norms is influenced by the external social surroundings.

3.2.3.1 Rational Choice Model

The rational choice model (sometimes called the rational-economic model) argues that conservation based decisions can be influenced if consumers are provided with information relating to financial and performance advantages of alternative choices, enabling them to act accordingly. The model is often used as guide for policy makers (Jackson, 2005) and states that consumers will calculate the individual costs and benefits of various courses of action choosing the option(s) that maximises their expected benefits. This is based on the assumption that: the foundations for human behaviour are based in self-interest, and; rational behaviour is the result of cognitive deliberation. Within the rational choice model, consumers require access to sufficient information in order to make informed choices about all the available options. However, Jackson (2005) notes that individual decisions do not always account for social costs or wider environmental interests, therefore information on these costs and benefits must also be issued to customers.

The rational choice model also fails to acknowledge that an individual's ability to take deliberative actions is limited by the way that individual responds to affective or emotional influences. Cognitive deliberation is often completely bypassed because individuals use a variety of mental 'short-cuts' - habits, routines, cues, heuristics – which reduce the amount of cognitive processing needed. Thus a degree of routine enters our behaviour, making it much more difficult to change and undermines a key assumption of the rational choice model (Jackson, 2005).

3.2.3.2   Theory of Planned Behaviour

Ajzen's (1991) 'theory of planned behaviour' built on Ajzen and Fishbein's (1980) 'theory of reasoned action' and is a well-known attitude behaviour model. According to the model (shown in figure 4) the key factors influencing behavioural intention are:

- Attitudes towards the behaviour

- Subjective norms and

- Perceived behavioural control or agency.

Figure 4: Theory of Planned Behaviour
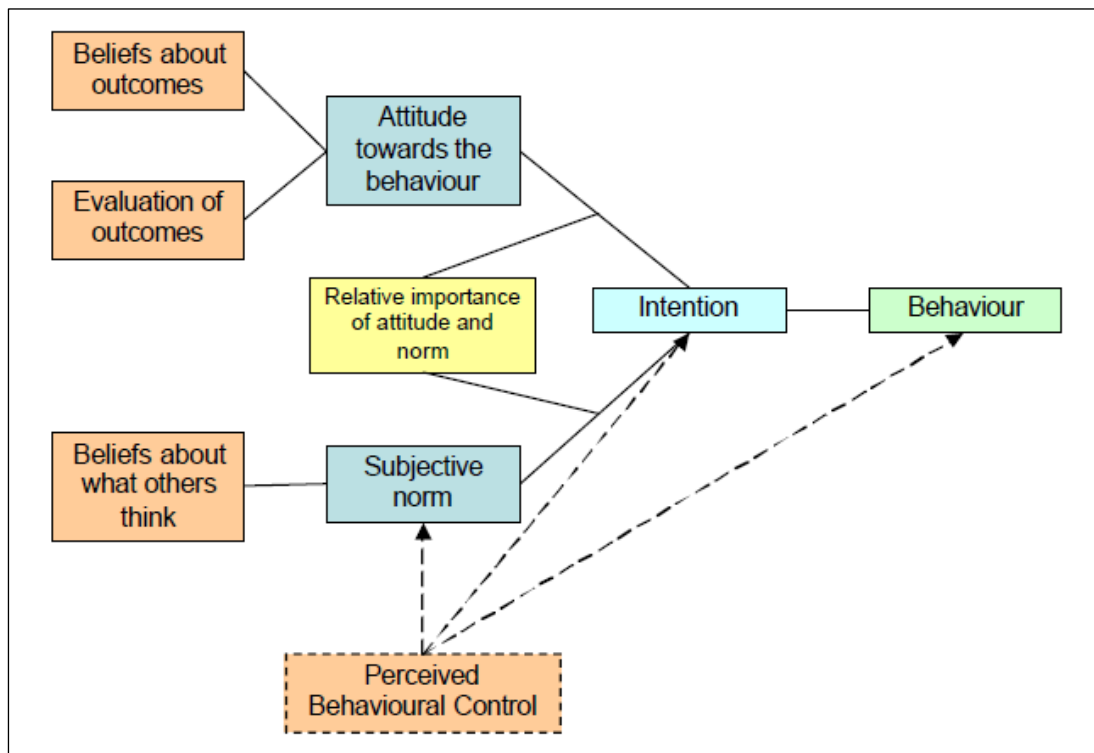
(Source: Jackson, 2005, p. 46).

The model states that intention leads directly to behaviour. The Theory of Planned Behaviour is an 'adjusted expectancy value model', whereas an 'expectancy value' model is based solely on attitude. The Theory of Planned Behaviour recognises the influence of the 'subjective norm' (that is, how socially acceptable an individual believes their behaviour to be). It also includes 'Perceived Behavioural Control' (PBC), defined in this case as the ease (or otherwise) of performing the behaviour in question. For these reasons, the model is seen as providing a more accurate prediction of behaviours than models based solely on attitude. However, the Theory of Planned Behaviour remains an intention-based model and assumes that intentions will be maintained. The model does not take into account cases where actors have incomplete volitional control (will, or cognitive process of deciding and committing to a course of action). It argued that these cases outnumber those in which volitional control is achieved or even achievable (Jackson, 2005). Given that behaviour is driven by many factors other than intention, the model may be more effective at predicting intention than actual behaviour. There is also limited attention to the constraints or drivers of behaviour external to the individual, such as environmental factors. 'Perceived Behavioural Control' is one element of the Theory of Planned Behaviour which attempt to overcome the constraint of simple attitude-behaviour models (Jackson, 2005). PBC is an indicator of both intention and action and can be described as a person's belief as to how easy or difficult it is to perform a particular behaviour (Ajzen and Madden, 1986).

PBC has similarities with the concept of self-efficacy, which Bandura (1982) proposed as:

> *'judgements of how well one can execute courses of action required to deal with prospective situations'* (p. 122)

The self-efficacy belief is adopted in a number of ways, including personal experiences (good or bad) and by modelling upon other's examples (Bandura, 1982). Perceived self-efficacy can determine whether an individual undertakes a given task, the degree of persistence when the individual encounters difficulties, and ultimate success. There is evidence to support the idea that people's actual behaviour is strongly correlated with their confidence of their ability to conduct an action (Jackson, 2005). This evidence is cited by Ajzen (1991) to claim support for the concept of PBC. However, evidence has found that self-efficacy and PBC can have distinct and independent effects on intentions (Armitage and Conner, 1999). Self-efficacy and PBC can also be considered forms of 'Agency'. The concept of

agency appears in most social-psychological models, but in a variety of different guises. Agency can be broadly defined as an individual's sense that they can carry out an action successfully, and that that action will help bring about the expected outcome (Darnton, 2008).

The Theory of Planned Behaviour has been applied widely to the task of understanding behaviour, and it is a model frequently used in the literature to explore pro-environmental behaviour (Jackson, 2005), which also includes attention to energy conservation. Applications of the model to what is often called 'environmentally significant behaviour' (Stern 2000) include attempts to use it to understand or predict behaviours related to energy consumption among other 'environmental behaviours' (Staats, 2003; Wall et al., 2004). Many of these studies fail to measure actual behaviour, and concentrate mainly on measuring the relationship between attitudes, intentions and PBC (Jackson, 2005).

3.2.3.3   Theory of Interpersonal Behaviour

The Theory of Interpersonal Behaviour is an integrative theory which takes a multidimensional view incorporating both internal and external elements in determining behaviour. The Theory of Interpersonal Behaviour was first outlined by Triandis (1977), who identified the key role played both by social factors and by emotions in forming intentions. The Theory of Interpersonal Behaviour attempts to explain how behaviour patterns result from a combination of what is intended, habitual responses, and situational constraints and conditions under which a person operates (i.e. facilitating conditions or external elements). In the Theory of Interpersonal Behaviour, intentions (as in the Theory of Planned Behaviour) are immediate antecedents of behaviour (Jackson 2005). Intentions are influenced by social, normative and affective factors as well as rational deliberations. Triandis (1977) highlighted the importance of past behaviour, or habit, in mediating present behaviour. Figure 5 shows Triandis' Theory of Interpersonal Behaviour.

In Triandis' Theory of Interpersonal Behaviour, intentions have three distinct antecedents:

- Attitudes or the perceived value of expected consequences

- Social factors, including norms, roles and self-concept

- Affective factors, or emotional responses.

Figure 5: Triandis' Theory of Interpersonal Behaviour
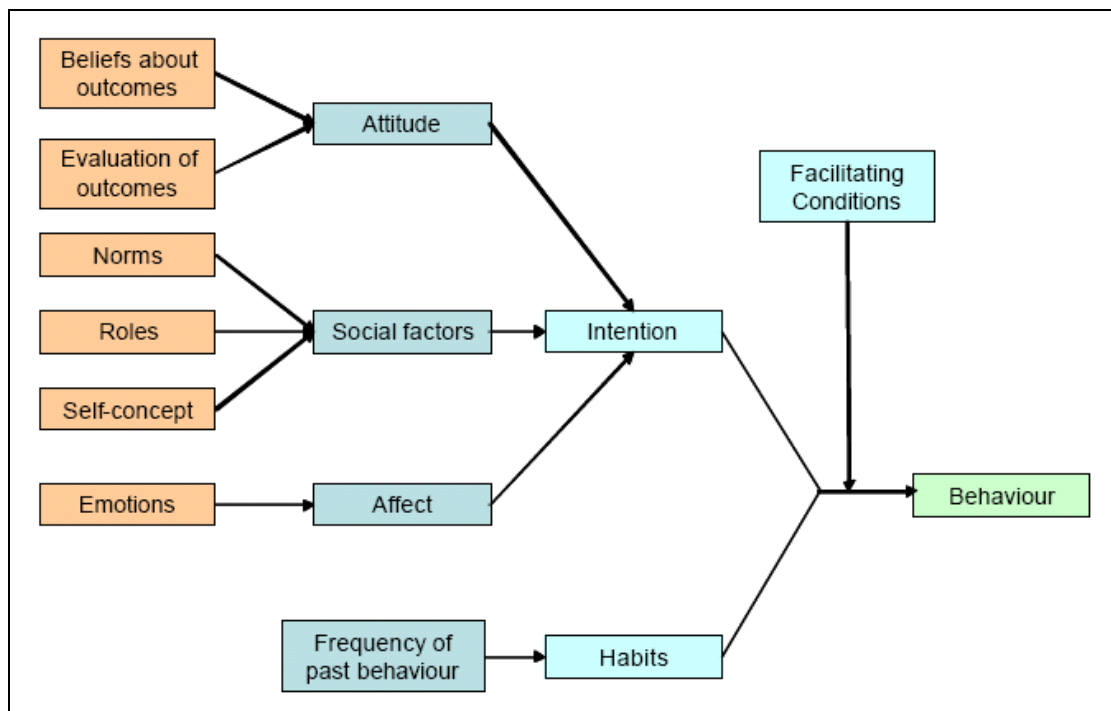
(Source: Jackson, 2005, p. 94)

Jackson (2005) describes social factors to include:

▪ Norms: social 'rules' about what should and should not be done

▪ Roles: sets of behaviour that are considered appropriate for a particular person in a particular situation

▪ Self concept: the self assessment of one's self and what activities one should pursue and engage in.

In framing an intention, an individual's emotional response to a decision may depend on rational instrumental evaluations of consequences, and may include both positive and negative emotional responses of varying strengths.

According to Jackson (2005), the Theory of Interpersonal Behaviour captures many of the criticisms levelled at the Rational Choice Theory. It can also be used as a framework for empirical analysis of the strengths and weaknesses of the component factors in different kinds of situations, and would be suitable for application to pro-environmental behaviour. It is often overlooked due to its greater complexity or lack of regard for the attitude-behaviour model. According to the theory, behaviours are neither fully deliberative, nor fully automatic; and neither autonomous nor social.

They are influenced by moral beliefs, but the impact of these is moderated by emotional drives and cognitive limitations.

3.2.3.4   Needs Opportunities, Abilities Model

The Needs Opportunity, Ability (NOA) model of consumer behaviour by Vlek et al (1997) considers macro-level societal factors rather than the individual level, for instance technology and the economy. According to Darnton (2008) these types of models are important to those developing policy for behaviour change as often it is necessary to work on the contextual factors limiting behavioural options directly; simply changing a person's perceptions of these material factors (e.g. cost) will not be sufficient to enable change.

The NOA model consists of an intention-based model of individual behaviour 'nested' within a model which shows the influence of macro-level environmental factors (see figure 6).

Figure 6: Vlek et al's Needs Opportunities, Abilities (NOA) Model
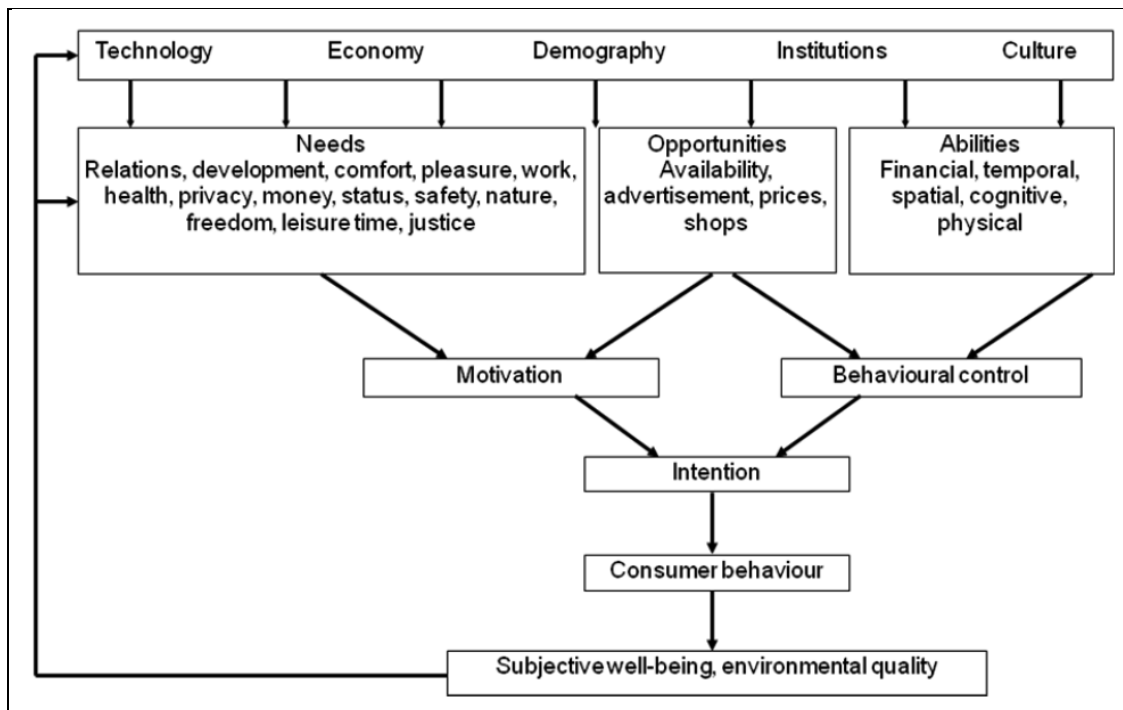
(Source: Gatersleben and Vlek, 1998, p. 146)

At the individual level, intentions are formed through both 'motivation' (driven by needs and opportunities) and 'behavioural control' (agency) (driven by opportunities and abilities). At the macro level, needs, opportunities and abilities are influenced by

the five environmental factors at the top of the model: technology economy, demography, institutions and culture (Gatersleben and Vlek, 1998). The model shows that consumer behaviour influences the societal factors, by means of a large 'feedback loop' running from the bottom of the model to the top (Darnton, 2008).

The NOA shows how environmental factors can influence behaviour and shows clearly that focusing only on personal factors alone will not necessarily bring about behaviour change. The NOA emphasises the interaction between individual and society, and demonstrates the need for interventions to work on multiple levels of scale (Gatersleben and Vlek, 1998).Vlek et al's, (1997) Needs Opportunities and Abilities Model, begins to step back from the focus of the individual which often characterises the field of social psychology and attempts to take in societal and technical drivers of behaviour.

3.2.3.5   Attitude-Behaviour-Context Model

According to Jackson (2005) the development of the Attitude-Behaviour-Context (ABC) Model, (see figure 7) by Stern (2000) and his colleagues (Guagnano et al., 1995; Stern et al 1999), attempts to overcome the internalist-externalist dichotomy in the social psychological literature. Core to Stern's approach is the understanding that behaviour is a function of the organism and its environment. In the language of ABC, behaviour (B) is:

> *'...an interactive product of personal sphere attitudinal variables (A) and contextual factors (C)'* (Stern 2000, p. 415)

Attitudinal variables considered in such theories might include a variety of specific personal beliefs, norms and values as well as general 'pre-dispositions' to act in certain ways.

Figure 7: Stern's Attitude-Behaviour-Context Model applied to recycling
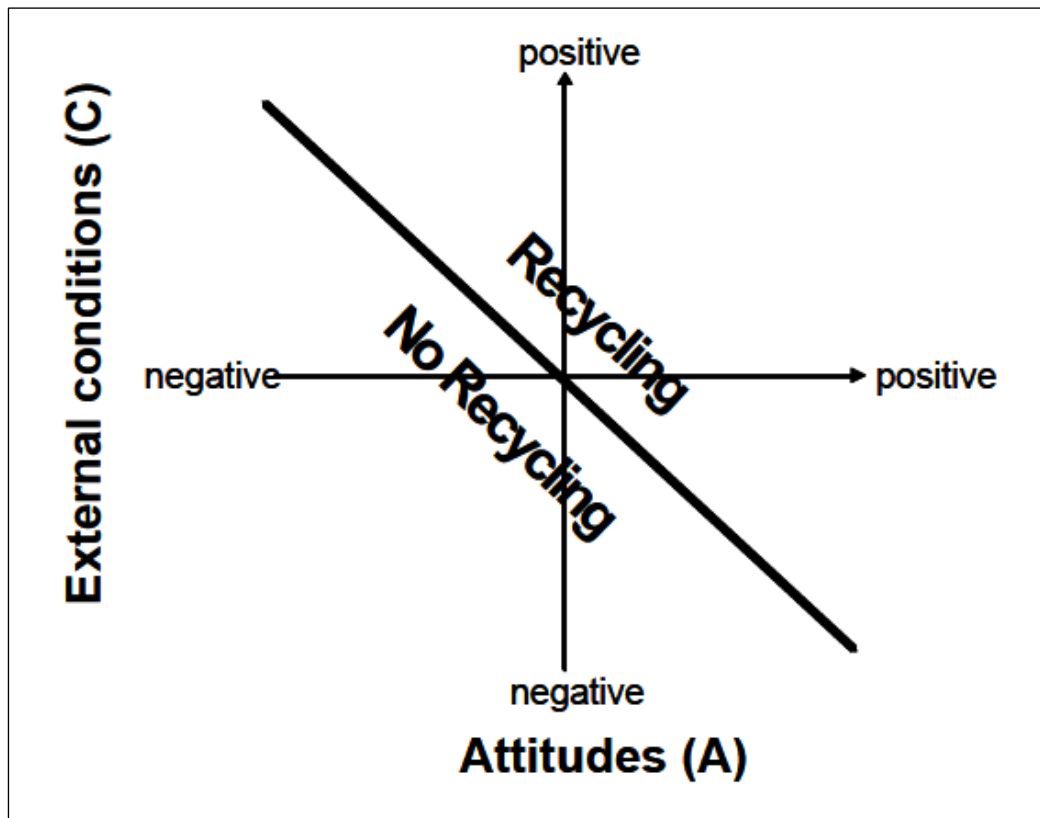
(Source: Jackson, 2005, pp 92)

Contextual factors can potentially include range of influences such as: monetary incentives and costs, physical capabilities and constraints, institutional and legal factors, public policy support, and interpersonal influences (social norms). The structural interplay between the influence of attitudes (i.e. internal factors) and contextual (i.e. external) factors is a principle component of the ABC model. Proponents of the model claim that the attitude-behaviour link is strongest when contextual factors are weak or non-existent; and that, conversely, there is virtually no link between attitudes and behaviours when contextual factors are either strongly negative or strongly positive (Jackson, 2005).

To use recycling as an example (see figure 7), according to Jackson (2005) having positive attitudes to recycling is much less relevant when access to facilities is either very hard or very easy. If it is very hard to recycle virtually no-one recycles, if it is very easy, most people recycle. In a situation in which it is possible but not easy to recycle, the correlation between pro-environmental attitude and recycling behaviour is strongest. Guagnano et al (1995) found empirical support for this hypothesis in a study of kerbside recycling.

3.2.4 Habit

Often, reasoning or deliberation has a lesser role in driving behaviour, especially when behaviour is repeatedly performed and becomes a habit (Verplanken et al., 1997). Stern (2000) describes habit as an individual's 'standard operating procedure'. In the Theory of Interpersonal Behaviour (Triandis, 1977)habit is seen as the primary determinant. Triandis defines habit as:

> *"situation-behaviour sequences that are or have become automatic…"*
>
> (Triandis, 1980, p. 204, in Bamberg and Schmidt 2003).

It is this automatic element of habit that differentiates it from repeated behaviour. Most frequent behaviours which are undertaken at lower levels of consciousness and not deliberated have a large habitual component (for example, turning out the lights in unused rooms) (Stern, 2000). Contrary to theories routinely used in social psychology, such as The Theory of Planned Behaviour (Ajzen,1991) behaviour does not typically follow intent, but is the product of habit. According to Wood and Neal (2007):

> *"Habits emerge from the gradual learning of associations between responses and the features of performance contexts that have historically covaried with them (e.g., physical settings, preceding actions). Once a habit is formed, perception of contexts triggers the associated response without a mediating goal"* (p.843)

When an action is repeated several times to an individual's satisfaction, deliberation over the action is reduced and it becomes more automatic; this habitual action is automatically triggered in particular circumstances without mediating a goal, for instance 'I need to go to the shop, so I will drive' (Verplanken et al., 1998; Verplanken and Wood, 2006). Many energy and transport behaviours are habitual, making them more resistant to change (APA, 2009; Nye et al., 2010). In particular, using conventional communication approaches to change behaviour will have minimal impact because habits undermine attention to information regarding other possible courses of action (Verplanken et al., 1997). Instead, habits need to be disrupted either by individuals making specific plans to carry out alternative actions or by using (or creating) changes in the environment in which individuals act, in order to force individuals to reconsider their behaviour options (Verplanken and Wood, 2006). For example, travel habits are broken when people relocate or change employer; hence provision of information about public transport just after people have moved house is much more likely to encourage a change in travel mode,

compared to providing this information under stable behavioural contexts (Bamberg, 2006; Verplanken et al., 2008).

Heijs (2009) notes that findings from applied social scientific research on energy-related behaviour show that habits are often better predictors of buying actions and energy consumption than variables used in the predominant social psychological models on attitude-behaviour relationships. Hejis (2009) also notes that the literature does not present an unambiguous definition of habit and theoretical models are scarce, and goes on to emphasise that this causes varying operationalisations of habit to be used (e.g. 'repeated behaviour in the past' or 'lifestyle'), and a large range of activities to be possibly relevant (more or less specific, frequent, conscious or automatic). Furthermore, Hejis (2009) emphasises that there is not enough insight into the origin, the development, and the function of habits within the social context of a household.

The concept of habit is also linked to Practice Theory which will be discussed in the next section. Practice Theory stems from the field of sociology and is markedly different in approach to understanding behaviours. The focus of Practice Theory is the social and institutional context of action rather than cognitive or affective 'drivers' of behaviour. It seems to come from a view-point where the theory of psychology is turned upside down. Within Practice Theory the question: '*How does an individual cognitively develop habits through their behaviour?'* may be rephrased to ask; *'How do habits seek us and engage us as agents to provide our time and dedication to maintain them?'* (Shove, 2009a).

3.3   Practice Theory

Practice Theory pays little attention to behaviours, but holds 'social practices' themselves as the central unit of enquiry. Practice Theory emerged in the 1970s (Austin and Sallabank, 2011) and is embedded primarily in sociology and influenced by thinkers such as Bourdieu (1977), Foucault (1977) and Giddens (1984). In Practice Theory the individual (for instance, in the role of consumer), often the focal point of behaviour change studies, is considered superficial to the analysis process and is sidelined to the background of the analysis. Along with the individual, the motivational mechanisms which, in the field of psychology, are widely deemed to shape intentions, and so drive behaviour, are also marginalised. Thus attitudes are very rarely referred to in Practice Theory: human conduct does not stem from an

individual's inherent attitudes or motivations, but through the ongoing interaction between 'discursive and practical consciousness' (mediated by lifestyles) on one side, and 'structure' (as rules and resources) on the other (Spaargaren and van Vliet, 2000).

In Practice Theory agents do exist, but they do not function as owners or originators of behaviour, instead they act as 'carriers of a practice' (Reckwitz, 2002). When discussing practice, commentators do not speak of attitudes, instead they talk of 'dispositions', or 'meanings', which are socially-constructed, and take place at specific points in time and space, because of an individual's particular direction and actions an individual has engaged with up to a point (Pred, 1981). As Shove (2010) states in her paper: *'Beyond the ABC: climate change policy and theories of social change'*:

> *"There is little or no reference to attitude or belief in any of this literature, and where such reference is to be found, needs and desire are located as outcomes of socio-technical change, not as external drivers of it"* (p.1278)

In comparison to understandings of behaviour based on social psychological assumptions, Practice Theory is completely different in its terminology and entire philosophical approach. Practice Theory is progressively infiltrating the mainstream, especially in connection with the study of environmentally-significant patterns of everyday consumption (McMeekin and Southerton, 2007, Hargreaves and Nye 2009; Gram-Hanssen, 2010). Efforts are being made to mobilise this dispersed body of theory for policy purposes (Darnton et al., 2011) where psychological theory is the dominant paradigm in circles of contemporary environmental policy (Shove, 2010). Respectively, Practice Theory is illustrated here as a distinctive approach to interpreting behaviour related to energy use.

Drawing on the 'theory of structuration' (Giddens, 1984) which influenced the development of Practice Theory, Spaargaren and van Vliet (2000) have produced a 'conceptual model for studying consumption practices', see figure 8 below:

Figure 8: Conceptual Model for Studying Consumption Practices
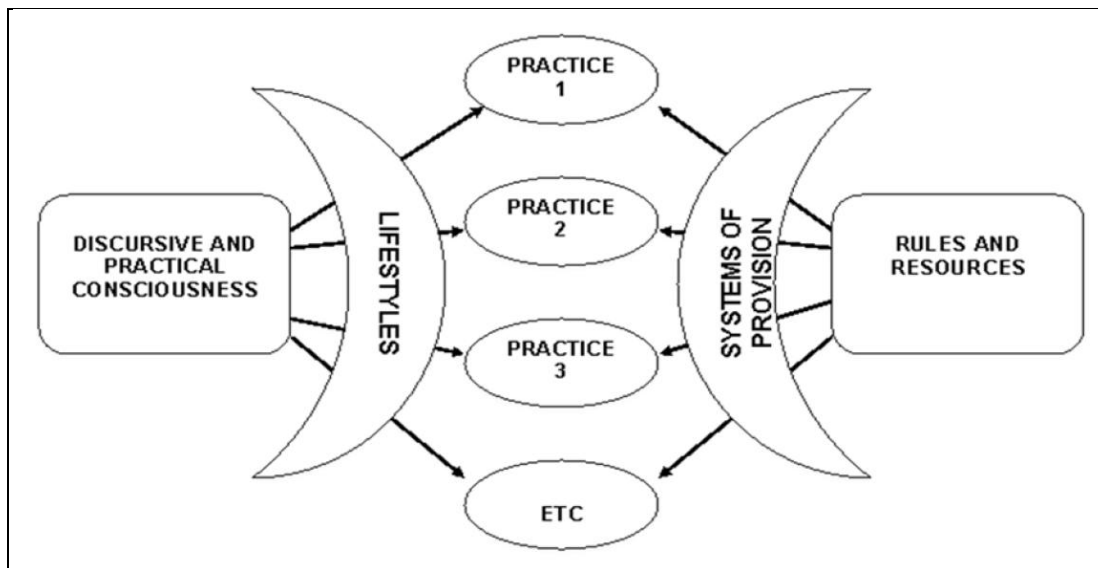
(Source: Darnton et al., 2011, p. 26)

This conceptual model (figure 8) emphasises that through Giddens' structuration theory the analysis of behaviour focuses mainly on the social practices which human agents participate. Individual behaviours and underlying reasons, interests and motives are studied in the context of social practices situated in time and space and shared with others. Beliefs, norms and values related to action do not therefore exist in a 'social vacuum', as often is the case with social-psychological models but in a context. Beliefs, norms and values are analysed as 'rules' which belong to social practice shared with others. The 'power' of the actor to change the course of action is specific to context and dependent on the 'resources' that are understood in the reproduction of social practice (Spaaragaren and van Vliet, 2000).

Spaaragaren and van Vliet (2000) emphasise the 'duality of structure' which refers to the dual character of the rules and resources involved in the (re)production and transformation of social systems. They note that social systems are sets of social practices and that on the one hand, actors are 'forced' in their actions to draw on existing rules and resources, using structures as a 'media' enabling a human actor to act. On the other hand, the same structures are in turn confirmed and reinforced by the actors' very actions. Thus, Spaaragaren and van Vliet (2000) argue that structures are both media *and* outcomes of human action. In addition they stress that study should aim for a balanced view of practices: not over-emphasising individual factors (lifestyle) or infrastructure (systems of provision), but focusing on the interaction between the two.

This concept of duality of structure influenced the development of Practice Theory along with Bourdieu's (1977) concept of 'habitus'. 'Habitus' can be described as a group of socially learned dispositions, skills and ways of acting that are acquired through activities and experiences of everyday life, and often taken for granted. As Bourdieu (1984) states:

> *"Habitus is neither a result of free will, nor determined by structures, but created by a kind of interplay between the two over time: dispositions that are both shaped by past events and structures, and that shape current practices and structures and also, importantly, that condition our very perceptions of these"* (p. 170)

Briefly described 'habitus' is a structure of the mind defined by a set of acquired schemata, sensibilities, dispositions and taste. The specific contents of the 'habitus' are the product of the objectification of social structure from the individuals own subjectivity. Therefore, the 'habitus' is defined as being isomorphic with the structural conditions in which it emerged (Scott and Marshall, 2005). Bourdieu (1977) also expands on the notion of 'habitus' by emphasising its dependency on history and human memory.

Bourdieu's and Gidden's work is accompanied by many other thinkers from a range of backgrounds that influenced the development of Practice Theory, which is not considered to be a unified theory but a group of theories (Schatzki, 2001). Reckwitz (2002) noted that in its range of approaches 'Practice' Theory in its singular represented an emphatic term to describe the whole of human action. That 'practices', however, in the sense of the 'theory of social practices' had a completely different emphasis and was appropriate for the more specifically focused field of study on human action. Reckwitz (2002) therefore encouraged a narrower focus of practice theory towards 'social practice', nevertheless the central unit of enquiry in practice theory or social practice is 'practice(s)', rather than 'behaviour(s)' as in the psychology literature. In his work 'Towards a Theory of Social Practices' (2002); Reckwitz describes practice:

> *"A 'practice' (Praktik) is a routinised type of behaviour which consists of several elements, interconnected to one another: forms of bodily activities, forms of mental activities, 'things' and their use, a background knowledge in the form of understanding, know-how, states of emotion and motivational knowledge"* (p.249)

More recently the elements identified by Reckwitz (2002), have been refined to the point that social practice can be described as being the resulting product of three interconnected elements:

- Material (objects, 'things' in Reckwitz (2002), also infrastructure)

- Image (symbolic meanings, conventions ideas and interpretations)

- Competence (procedure, skills)

(Shove, 2009b)

According to Shove (2009b) practice is a process on integration of these three elements of 'material', 'image' and 'competence', resulting in a structured arrangement, i.e. resulting in a practice that exists (for a time) as a recognisable entity. Figure 9 shows all three elements integrated to form a practice.

Figure 9: The integrated elements of a practice
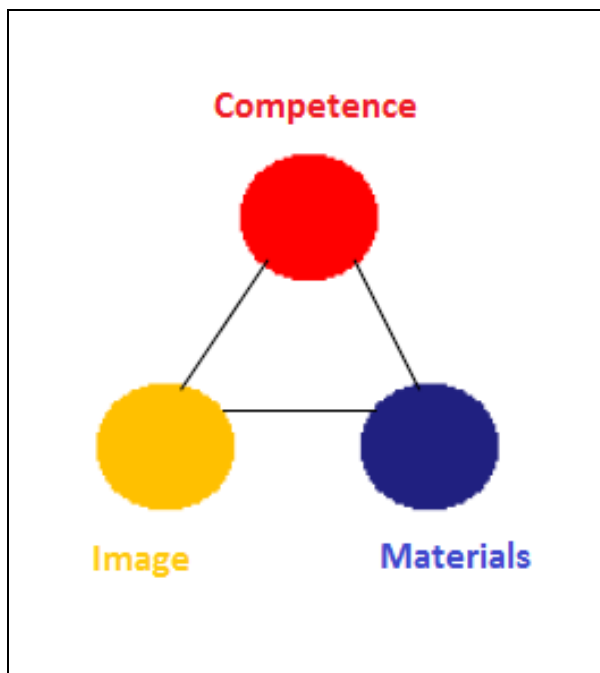
(Adapted from: Shove, 2009b)

'Innovations' in practice occur when people make new connections between existing or new elements of 'material', 'image' and 'competence'. Thus practices are made, sustained and reproduced through processes of making and breaking links between elements (Shove, 2009b). Figure 10 shows these processes of, 'proto-practices', before elements are integrated, 'practices', when elements are integrated, and 'ex-

practices', when elements break up and the practice ceases to exist as an entity (Shove, 2009c).

Figure 10: Proto-practices, practices and ex-practices
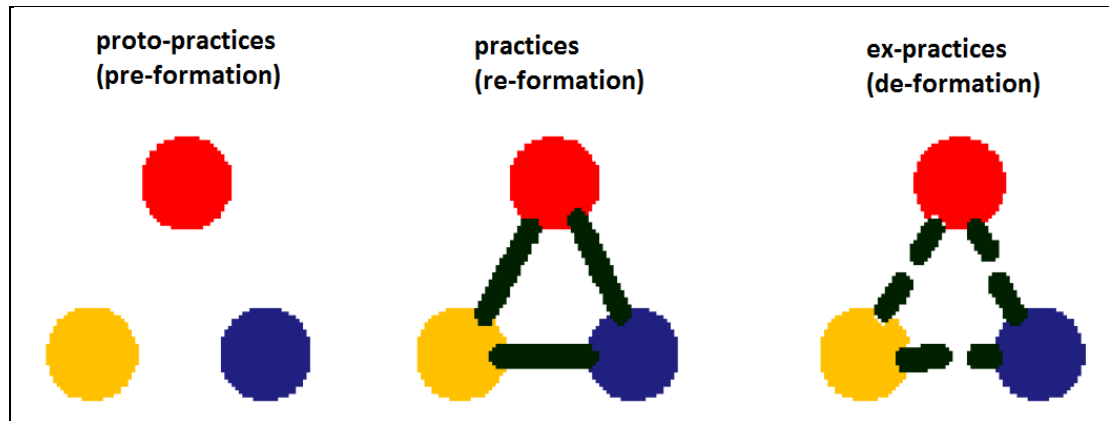
(Adapted from: Shove, 2009c)

Practices are complex: elements circulate, practices can 'bundle' and they can fragment and stabilise again (Shove, 2009b), as figure 11 shows.

Figure 11: The complexity of practices
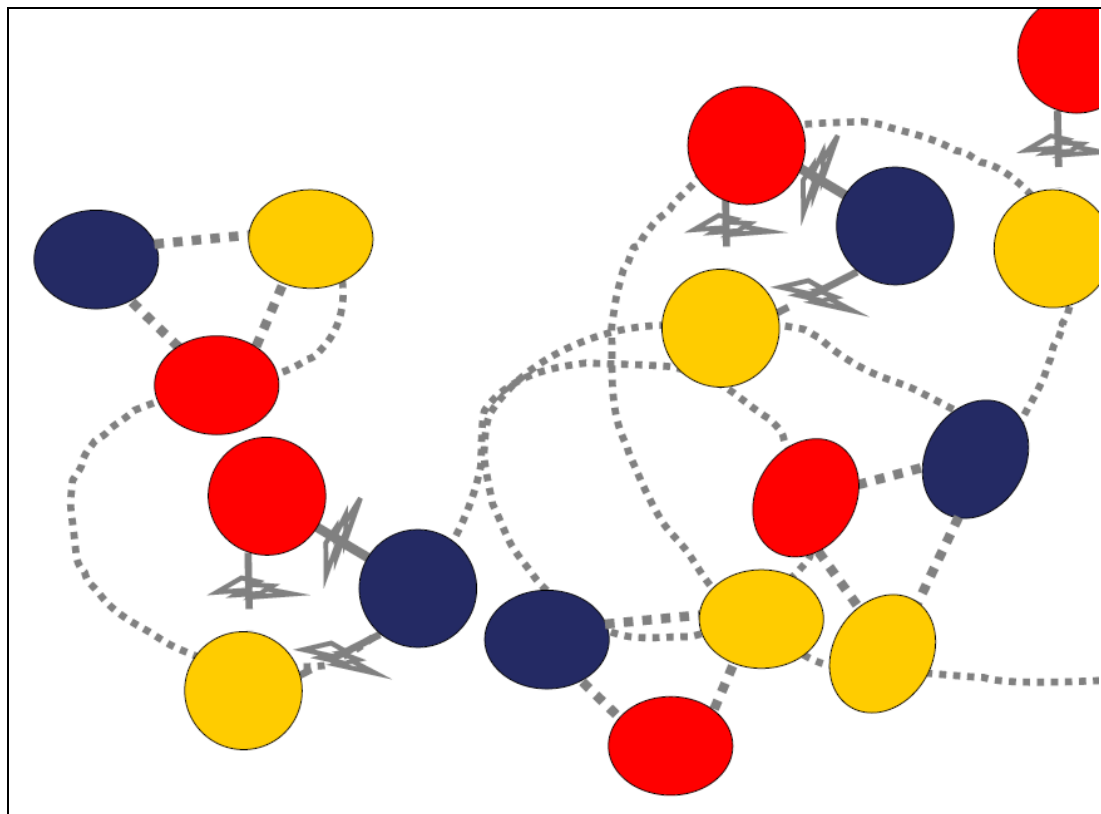
(Source: Shove, 2009c, p. 13)

Hand et al. (2005) have illustrated these elements in the context of the practice of daily showering. In this case, 'image' is the ideas of getting clean and fresh daily as being socially acceptable and correct; 'material' would be the plumbing infrastructure, water heating and showering equipment; 'competence' the skills and knowledge to make that equipment work, and to fit the practice around other daily practices. Practice-based studies such as this are useful for explaining everyday practices such as showering. After looking through a practice lens, the idea that people might be regularly deliberating over the choice of whether to, or how to shower, and that their personal attitudes are drivers of that decision and behaviour becomes unlikely. Practice Theory could be applied to all behaviours, regarding them as habitual or routine formed out of the interaction between individual and society, then carried and replicated by others.

'Practice'-focussed accounts offer an alternative perspective to 'attitudes', focussing on the social and institutional context of action rather than cognitive or affective 'drivers' of behaviour. This shifts attention away from the individual as the unit of enquiry to the socially-constructed meanings associated with action. Practice accounts also highlight the point that energy consumption/carbon impacts are a by-product of particular practices; 'behaviours related to energy use' are not a recognisable suite of behaviours in this case (theoretically or for the general public). Energy use is a form of consumption as the consequence of a range of different social practices as Warde (2005) points out:

> *"Consumption occurs as items are appropriated in the course of engaging in particular practices"* (p. 131)

Accordingly, much consumption is 'inconspicuous', and energy consumption in particular is 'invisible' (Shove, 2003). Although this practice perspective is in contrast with the psychological perspective on energy related behaviour, many psychologists and sociologists share a recognition that behaviours related to energy use are often routinised/repeating. Both perspectives agree that routine is a large determinant of behaviour rather than the outcome of conscious deliberation and that changing attitudes may do little to change behaviour.

Much of the work adopting a practices paradigm to examine environmental implications has focussed on energy consumption in domestic households. Shove and Southerton (2000) examined the adoption of the freezer in British households and the way in which this appliance (accounting for 26% of energy consumption by

electric appliances in 1995), increased from an ownership rate of 3% of households in 1970 to 96% by 1995 (DECADE, 1995, in Shove and Southerton, 2000). This account provided by Shove and Southerton (2000) is relevant to the uptake of any domestic technology, including the introduction of energy efficient technology or appliance that consumes more energy. This example is framed not in terms of attitudes or the functions performed by the object, but in terms of the way in which freezers have fitted into the changing organisation of domestic life, particularly the increasing participation of women in the workforce and associated sales narratives. Shove and Southerton (2000) also point out the symbiotic relationship between the freezer and another kitchen appliance –the microwave oven, capable of rapid defrosting. The freezer is described as being 'chameleon-like' through the decades, a symbol of modernization in the 1970s, a pre-condition for domestic and economic efficiency in the 1980s and a device of convenience in the busy 1990s –a 'time-machine' that plays its role in a kitchen that is now designed around its appliances. Moreover, Shove and Southerton (2000) emphasise that the freezer partly creates the conditions that it alleviates –by helping to solve the problem of limited domestic time under conditions of increased working hours, it in part perpetuates that condition by enabling it to continue. This illustrates that the problem of increased domestic energy consumption is framed in terms of its social context of changing female labour patterns, company sales narratives and domestic practices, rather than attitudes to any of these phenomena, individuals' 'needs' or related 'behaviours'.

The Practice Theory perspective thus provides an insight into human actions related to energy use which helps to illustrate that human actions are not necessarily a product of an individual's attitudes or intentions. Instead, human actions are forged from the interaction and integration of elements of 'images', 'competencies' and 'materials' from a society, situated in space and time. Whereby, such elements, when integrated, can both determine practices *and* be determined (or be 'reshaped') by practices.

3.4   Comparing Psychological Theories of Behaviour with Practice Theory

Practice Theory and psychological theories of behaviour follow very different paths. One is based in the field of sociology and the latter in psychology. Darnton et al., (2011) help to illustrate the differences in table 5 below:

Table 5: Difference between behaviour and practice

Behaviour	Practice
Individual as Origin	Individual as Carrier
Caused by Drivers	Co-evolving
Consequentialist	Recursive
Individual Choice	Shared, Social
As if for the First Time	Within a Continuous Flow of Activity
Contextual Cues	Emergent Rules and Resources

(Adapted from Darnton et al, 2011, pp)

There appear to be a number of conceptual differences between the two approaches. Darnton et al., (2011) point out that the first area listed in the table is perhaps the most fundamental:

> *"behaviour is taken to be the product of individuals' motivations and capabilities, expressed through interaction in social groups and the wider world. Behaviour is thus the property of the individual, and hard to separate from them. By contrast, practices are relatively stable entities which are inherently repetitious and recognisable; they seem to have some independent existence of their own, such that individuals reproduce them when they act"* (p. 12)

The second distinction is taken to be the product of an array of factors –commonly called 'barriers and drivers' which combine in sequences, determine behavioural intentions, and which in turn trigger the end behaviour. In contrast to this practices are not the result of a series of factors, but the emergent outcome of elements (such as infrastructure and institutions) which already exist in the social world. Such differences outlined in the table suggest two distinct paradigms, but Darnton et al. (2011) interpret them as two overlapping strategies intervening for the purposes of encouraging sustainable lifestyles suggesting that:

"one would focus on individuals' motivations and resources, and work intensively with them to break or embed habits. The other would involve looking at the wider social world, and the aspects of 'hard' and 'soft' infrastructure which hold particular routine practices in place" (p. 13)

While the two approaches to habits (and behaviour) are conceptually distinct, Darnton et al's (2011) review concludes that both are needed to respond to the embedded everyday behaviours which have negative environmental impacts.

An interesting debate between Whitmarsh et al. (2011a) and Shove (2011) which is published commentary regarding Shove's (2010) paper, helps to define differences and compatibilities of the two approaches in addressing problems such as sustainability. In order to fully convey the main points of the argument, it was necessary to quote the large sections of the literature which follow. Whitmarsh et al. (2011a) argue that:

"...One of Shove's main critiques, we find, lies in the suggestion that the ABC ('attitude behaviour choice') model remains prevalent in policy circles, as it tailors with 'the dominant paradigms of economics and psychology' (page 1274).

Our reading suggests that her paper is restrictive in its simplistic portrayals of psychological models of behaviour, and wholesale dismissal of nonsociological approaches to social or behavioural change. It is frustrating especially in relation to sustainability where there has been some success in bringing together different disciplines towards similar aims and goals that different disciplinary perspectives continue to be perceived both as necessarily opposed and in opposition.

Sustainability is a complex and multi-layered problem evident at the levels of a range of perspectives, not one single worldview, theory or research methodology...Interdisciplinarity is increasingly valued and in contrast to Shove's claim that behavioural and practice perspective are "chalk and cheese" (page 1279) – there are many examples of successful interdisciplinary working which bring together sociological, psychological, and other approaches (e.g. Darnton, 2010; Devine-Wright, 2010; Upham et al, 2009; Whitmarsh et al, in press), for example to elucidate energy consumption and the potential for a sustainability transition within energy systems (Nye et al. 2010). It is disappointing, and frankly very worrying, if efforts such as these are dismissed because they include contributions from a range of backgrounds. We should be vigilant against claims that one particular perspective is the only, and correct, one – particularly when this view is one in which society must change but sees no role for citizens in directing or enacting this change." (pp. 258-260)

Shove (2011) then responds to the critique:

> *"...Since observation is itself theory laden (Hanson, 1981), contrasting paradigms are incommensurable on a number of counts. They generate different methods of enquiry, different meanings of evidence, and different sorts of research agendas. To revert to the terms I use in "Beyond the ABC", some paths are made of chalk and others of cheese. This is not something to worry about; nor is it an obstacle to be overcome...paradigms are not obstructions to knowledge production: they are conditions of it...*
>
> *...The issue...is not that alternative points of view have different 'strengths and weaknesses' or that the one perspective-plus-problem-definition can be added to another. Instead, and as is beautifully illustrated by the unusual structure of Darnton's report, "Unlocking habits/reconfiguring routines" (2010) different paradigms exist in parallel. When read from front to back this intriguing document provides a review of literature that treats habits as drivers of behaviour (chalk). However, if readers flip the document over, and start to read from the back, they will find a review of literature in which routines and practices are the central units of enquiry (cheese). Although Whitmarsh et al refer to this report as an example of a combined approach the 'flip-flop' format exemplifies the impossibility of producing a single theoretically integrated narrative...As Blaike makes clear, it is vital to acknowledge 'the different and incommensurate ontological and epistemological assumptions associated with various theories and methods' (1991, page 115). This does not mean that qualitative and quantitative techniques can never be combined, but it does mean that integration is possible only if founded on a coherent epistemology, and not on a mishmash of chalk and cheese!"* (pp. 264-263)

This debate illustrates that social psychology and practice theory, although from different backgrounds, can work towards sustainability problems in parallel if differences are acknowledged. In this PhD research, regarding the evaluation of occupant behaviour related to energy use, it would be naive to assume that any one discipline could provide a comprehensive insight into theoretical explanation of such behaviours. Hence this literature review has considered appraisals of behaviour from both Practice Theory and Psychology, in an attempt to understand the problem from different perspectives. They are completely different paradigms from contrasting perspectives, but both can be useful in explaining behaviour. Fundamentally different paradigms can run in parallel as a part of knowledge creation, and although sometimes divisions exist in approaches, perspectives from different paradigms can contribute to understanding behaviour related to energy use. However, it is not the intention of this research to attempt to combine elements of Practice Theory and social psychology approaches as an empirical approach. Rather, the analysis process this thesis draws on specific elements from both of the

disciplines to assist the interrogation of 'key patterns' identified in the findings so they may be better explained or understood.

So far this thesis has discussed the main theories related to behaviour as understood by psychological theories of behaviour and Practice Theory. As the key focus of this thesis is the evaluation of the impacts of a retrofit project on occupant behaviour related to energy use, this literature review now narrows the focus towards this particular theme.

3.5   Household Behaviour Related to Energy Use

According to the literature, households use energy in a direct and indirect way, this research focuses on direct energy use. Direct energy use is the use of electricity, gas and other fossil fuels. Indirect energy usually refers to the energy used in the production, transportation and disposal of goods and services. In European countries, about 50% of total household energy use can be defined as direct energy use and in the UK about 40% (Kok et al., 2003; Reinders et al., 2003). Households use energy for a number of different purposes and in the UK in 2008, proportions of domestic energy use related to space heating 66%, water heating 17%, household appliances 12%, lighting 3% and 3% to cooking (Palmer and Cooper, 2011).

As noted in section 1.1.2, the amount of energy used in homes is largely dependent on the behaviours of the occupier (Smith and Pett, 2005; Janda, 2009; Gill et al., 2010; Stevenson and Leaman, 2010) and the importance of social factors in determining the effectiveness of retrofit programmes should not be ignored. Retrofit implementers (such as social housing providers, and local authorities) assume that energy efficient technologies retrofitted to housing will reduce energy consumption, carbon emissions and fuel costs by a particular amount, however the occupants' behaviour related to energy use will influence these factors (Smith and Pett, 2005; Janda; 2009; Gill et al., 2010; Stevenson and Leaman, 2010; Morley and Hazas, 2011).

A study by Morely and Hazas (2011) compared evidence of energy consumption variability from previous research. The study found that energy use in households living in identically-designed buildings varied, supporting the claim that the occupant has a unique influence (of some kind) on energy consumption. Through qualitative investigation, the research identified practices that varied between households, both

within the same practice and in terms of distribution. Some of these differences could help explain the variance in aggregate levels of energy consumption but this could not be fully confirmed without detailed data on the energy profiles of these particular practices.

The actual effectiveness and impact of Technical Intervention on energy use and carbon emissions may be miscalculated without taking into account occupant behaviours associated with energy consumption, because alterations in occupant behaviours are difficult to predict (Leaman, et al., 2010; Morley and Hazas, 2011). Nevertheless, this issue is seldom considered in energy efficiency targets or carbon reduction targets when retrofitting homes. Thus, occupant behaviour is increasingly recognised as a crucial element to be acknowledged, understood and addressed (Gill et al., 2010; Stevenson and Leaman, 2010). The following sections focus on literature which is specific to understanding the energy use behaviour of household occupants, some of the factors which influence such behaviours and interventions which attempt to change behaviour related to energy use.

3.5.1 Factors Influencing Household Behaviour Related to Energy Use

Since the 1970s, a significant body of applied social psychology literature and environmental psychology literature has developed on energy consumption and conservation behaviour (e.g., Stern and Kirkpatrick, 1977; Brandon and Lewis, 1999). Four main theoretical approaches to understanding or accounting for energy use behaviours have emerged, each of which offers a unique perspective on the role(s) of actors in a transition to a lower carbon economy. The two most dominant of these are 'expectancy-value' approaches, which is based on the premise that how an individual evaluates the anticipated outcomes of behaviour in terms of rewards and costs will determine the individual's intention to act (Ajzen, 1991); and norm-based approaches, which focus instead on 'internal' rewards associated with adhering to personal values (Axelrod and Lehman, 1993). A well-established, but less dominant, branch of research highlights the role of unconscious processes, such as habit, on behaviour, including energy use (Verplanken et al., 1998). Recent efforts have also focussed on providing integrative theoretical frameworks that encompasses these diverse determinants of behaviour including attitudes values, beliefs, contextual forces, personal capabilities and resources, and habit (Stern, 2000).

In these studies, the emphasis is on social and psychological factors relating to energy-saving measures, e.g. cognitive factors or the social processes (van Oel et al., 2009). Energy use is mainly driven by economic (e.g. income, cost), structural (e.g. location, home ownership, household size), and social factors (i.e. status, meaning, identity, etc.) and by everyday (consumption) practices and habit; environmental values tend to have relatively little influence (Whitmarsh, et al. 2011b). Therefore, it would be misleading to assume that on the whole, everyday energy use behaviour is financially driven or even essentially rational. Research strongly indicates that energy use behaviours can, and often do, shift rapidly from considered deliberations over perceived personal costs and benefits to becoming more habitual (Bamberg and Schmidt, 2003; Gardner and Abraham, 2008). For example, survey research has found that 'habit' is a frequently given as reason for not switching off lights and appliances (Emmert et al., 2010).

According to a review by Steg (2008), the main factors influencing household energy use and energy conservation for individuals is that they: must be aware of the need for and possible ways to reduce household energy use; need to be motivated to conserve energy; and should be able to adopt the relevant behaviours. Further factors influencing household energy conservation are outlined in the section below.

Environmental Protection Rationale

In general, individuals are well aware of the environmental problems related to household energy use, and are concerned about these problems (Abrahamse, 2007), although there is still confusion about the causal processes involved (Bord et al., 2000). Despite awareness, people often do not act in line with their concerns and total household energy use is still rising (Poortinga et al., 2002;Abrahamse, 2007).

The literature notes the significance of an individual's motivations for energy conservation, identifying three main goal frames, which govern whole areas of sub-goals, knowledge and attitudes (Lindenberg and Steg, 2007). Lindenberg and Steg (2007) argue that they are highly relevant for environmental behaviour such as energy conservation and describe them as the '*hedonic*' goal 'to feel better right now', the '*gain*' goal 'to guard and improve one's resources,' and the '*normative*' goal 'to act appropriately'. When such a goal is activated (i.e., when it is the 'focal' goal, or a 'goal frame'), it will influence what persons think of at the moment, what

information they are sensitive to, what action alternatives they perceive, and how they will act.

Normative and environmental concerns are more important than hedonic or cost reasons as they provide the most solid basis for promoting energy conservation. People carrying out behaviour for hedonic or cost reasons will stop doing so as soon as the behaviour is no longer attractive or cost effective (Lindenberg and Steg, 2007). For example, people may choose to save energy when financial cost is high, but when the costs go down again energy behaviour reverts to previous trends. Energy conservation resulting from normative concerns (e.g. a prevailing belief that it is the right thing to do to save energy for the sake of the environment), is more robust to such changes which has important policy implications (Lindenberg and Steg, 2007).

Pro-environmental behaviour can be simplistically characterised as a product of both 'internal' (psychological) and 'external' (social, economic, physical) drivers and constraints (Stern, 2000; Nye et al., 2010). The literature on behaviour change consistently highlights the complexity in both determining and changing behaviour, which is influenced by multiple conscious and unconscious processes (Jackson, 2005). Important implications of this complexity are that: individuals' attitudes and actions are not necessarily consistent, see the 'value-action' gap (Blake, 1999; Kollmuss and Agyeman, 2002); and an individual's behaviour in one context may be inconsistent with their behaviour in another context. Despite recent interest in the notion of 'spill-over' effects across environmentally-beneficial behaviours, there is very limited evidence for this (Thøgerson and Ölander, 2006; Whitmarsh and O'Neill, 2010). Regardless of a person's environmental concerns, there are likely to be multiple reasons why a person makes a particular choice over the alternatives (or may not even consciously 'choose' a course of action at all, (Verplanken et al., 1998)). The reasons why someone cycles to work, for example, may include considerations of health benefits, cost, availability of showers and cycle paths, with environmental concern as an additional motivator; whereas the reason why the same person flies to Spain for a holiday may be based on a different arrangement of factors such as cost, time, convenience, and social convention (Anable, 2005).

Energy saving is not only driven by concerns about energy and environmental problems but driven by factors such as status, comfort and effort (Stern, 2000). People are less likely to reduce their energy use when saving energy incurs a high

behavioural cost in terms of money, effort or convenience. People are more likely to take up low cost and low effort environmental activities, such as using lower temperature settings heating on controls (Steg, 2008). However, some people do reduce their energy use even at a high cost and personal disadvantage (Lindenberg and Steg, 2007). Factors of thermal comfort and convenience are worth exploring and are discussed below.

Willingness to change energy habits, or at least stated willingness (i.e. surveys do not measure actual behaviour), does appear to be increasing. An Energy Saving Trust (2010b) survey indicates that the proportion of UK public stating that they are doing more to conserve energy in the home increased between 2008 and 2009. The survey also indicates that actions to save electricity and lighting are more popular than heat and washing related energy saving actions (EST, 2010b).

There are however both conceptual and attitudinal differences between purchase-related behaviours (including energy-efficient light bulbs and appliances) and so-called habits, which include energy curtailment behaviours such as reducing heat in unused rooms, reducing hot water temperature, and putting on more clothes instead of more heating. That is to say people perceive energy-efficiency measures and energy conservation as separate categories of 'behaviour'. Within the UK, a clear majority (70%) consider reducing household energy use as virtuous thing to do for the environment (Green Barometer, 2007), although policy measures aimed at reducing household energy use are generally unpopular: few think that measures, such as 'green' taxes (34%) and carbon rationing (28%) are socially acceptable. Similarly, enthusiasm of individuals for changing their lifestyles appears to have limited expression. A recent British survey (Spence et al., 2010) found that while 65% of people agree or strongly agree that they are prepared to greatly reduce their energy use to help tackle climate change, fewer than half of respondents (44%) are prepared to pay significantly more money for energy-efficient products.

In the research field of resource conservation behaviour, the environmental impact of humans on the individual, household or societal level has been generally attributed to the function of their numbers, affluence and technology they currently use (Ehrlich and Ehrlich, 1991; Vlek and Steg. 2007). Midden et al., (2007) have highlighted that, regardless of the ancient and ongoing relationship between human use of technology and the consumption of natural resources, technology is often set apart from the study of human behaviour in this context. Midden et al., (2007) have

explored the influence of technology on energy use behaviour and identified four roles in which technology can influence behaviour. This is of particular relevance to this PhD research and will be explored later in section 3.5.2.

Thermal Comfort

There is no absolute standard for thermal comfort (Darby and White, 2005). An internationally-accepted definition of thermal comfort, is 'that condition of mind which expresses satisfaction with the thermal environment' (ISO 7730:2005). Perceptions of this environment are influenced by air temperature, radiant temperature, relative humidity, air velocity, activity and clothing. General definitions of comfort include a sense of relaxation and freedom from worry or pain (Darby and White, 2005). Comfort conditions in general are socially influenced and may change with time as design, activity, technology, and clothing fashion change (Shove 2003). Thermal comfort is a factor that has a relationship with behaviour related energy use, and research is currently underway to further understand day to day comfort practices, control systems and the role of energy use feedback by working with home occupants (EPSRC, 2010).

In addition to the direct financial and environmental rewards, there are other benefits resulting from energy efficiency retrofits to be considered. An increase in the indoor temperature may be desirable because it: improves the health of the occupants, and reduces the adverse affects of condensation on the building fabric, resulting in lower redecoration and repair costs, therefore making the property easer to rent out and resulting in fewer voids for the Social Landlord.

Research by Milne and Boardman (2000) showed that there is a clear link between the average indoor temperature of a house before the installation of energy efficiency technology and the amount of potential benefit (energy savings) taken as extra warmth, referred to as a 'takeback' effect. This is influenced by a combination of physical and behavioural factors. Based on results from low income housing, at an estimated temperature of UK housing of 16.5°C, 30% of (total) potential energy savings can be lost through comfort 'takeback' with 20% (of total) lost if temperatures of housing are at an average of 19°C (Milne and Boardman, 2000).

A study exploring practices of thermal comfort for sustainable design by Kuijer and de Jong, (2011) found that a central heating system combined with insulation can

offer fairly constant indoor temperatures. However, this does not prevent people from feeling cold indoors. When sitting still in front of the television for example, people felt colder easier. While doing activities like cooking or cleaning little need for extra heat is felt. Furthermore there are moments of peak heat requirements when people feel the most need for heat, such as getting in or out of bed and getting out of the shower. Some parts of the body also get colder more easily than others.

If the socially desirable goals of affordable warmth, along with goals of energy conservation and carbon dioxide emission reductions, are to be achieved, the way in which behaviours and thermal comfort interact must be more thoroughly understood. This PhD research may provide further understanding of behaviours related to energy use and linked to thermal comfort, from an energy efficient retrofit context.

Convenience

Relating to their study of consumption, food and convenience, Scholderer and Grunert (2005) describe convenience as a multifaceted phenomenon suggesting that something can be done with reduced effort. Scholderer and Grunert (2005) focus on dimensions of time, physical energy and mental energy, alongside the stages of home food production to identify key points where effort is saved. Table 6 below shows a typology of food convenience from the food consumer's viewpoint, it shows what effort is being saved at what consumption stage and if this is time, physical energy or mental energy.

Table 6: A typology of convenience in meal preparation

Consumption stage	What is being saved?		
	Time	**Physical energy**	**Mental energy**
Planning	Habitual purchasing, weekly meal plans, intelligent fridge		Products arranged by recipe in shop, space management, intelligent fridge
Purchasing	One-stop shopping, home delivery	Help in packaging and checking out, good parking facilities, home delivery	Known store layout, automated reordering
Preparation	Ready-made meals, eating out, microwave ovens	Blenders and other kitchen appliances	Clear instructions
Eating	One course meals, stand-up food outlets	Pre-cut food, meat without bones	Familiar food, finger food
Disposal	One-way containers	Dish washer	

(Source: Scholderer and Grunert, 2005, p. 106)

Although the typology of convenience in table 6 refers to meal preparation the same overarching theme of effort, involving time, physical energy or mental energy can also be reflected in energy use behaviour convenience.

According to Shove (2003) the term convenience, originally referred to fitness for purpose, was adopted in the 1960s to describe arrangements, devices, or services that helped save or shift time. Since then, time-related use of the term has dramatically increased, with a range of commodities being sold as being convenient or making life more convenient for the user.

In Hand et al's (2005) interpretation of showering with reference to the temporal organisation of daily life, it is argued that 'speed' and 'convenience' are of defining importance and crucial in explaining both the general increase of showering, and the decline of bathing. It is argued that the key difference between bathing and showering is that the latter is associated with speed, immediacy and convenience. Hand et al. (2005) note the importance of the temporal and sequential scheduling of everyday practices and planning where showering and bathing fit in the daily or weekly routine. Also that the 'materials' or infrastructure providing constant availability of hot water and the concept of valuing of freshness may be related to the increased frequency at which people wash in recent times. Showering as an action is not inherently 'quick' but it has the potential to be so, especially compared to bathing. However the fact that showering is valued for its speed and convenience is in keeping with the general consensus in society that everyday life feels increasing 'harried' (Southerton and Tomlinson, 2003).

Hand et al. (2005) suggest a symptom and possibly a cause of this feeling of restricted time is the notion that time is a precious commodity that can be organized and managed through the careful sequencing of daily life (Southerton, 2003). Domestic tasks are broken down into their component parts and (re)organised to maximize temporal efficiency. The labour saving devices have a role to play in this process and ideology according to Schwartz-Cowan (1983). Some devices have made it possible to reduce the amount of time devoted to certain tasks, however the frequency of such tasks have often increased. This has resulted in temporal structures full of small episodes of attention, thus in this context the ability to 'slot in' a five-minute shower is appealing where a bath does not 'fit in' to the temporal structure (Hand et al., 2005). According to Warde (1999), showering is one of many domestic devices that has grown in popularity because they promise to help

individuals cope with the temporal challenges of (late) modern life. Thus, Hand et al. (2005) emphasise that practices are not held in place by technological or cultural considerations alone. While showers are not by definition, long or short, it is in relation to social conventions of time pressure, that people have come to understand showering as a technology of 'convenience'

Warde et al. (1998) note the distinction between 'modern' and 'hypermodern' forms of convenience, arguing that the former relates to the reduction of time taken to achieve a given goal and that the latter is about storing or shifting time, thus providing people with greater flexibility or control over their own schedule. 'Hypermodern' convenience devices (such as the freezer, e-mail, the car, or the video), promise to alleviate some of the pressures faced by those individuals leading busy lives and who feel pressed for time (Southerton et al., 2001).

A study by Edwards and Pocock (2011) suggests that behaviour related to energy consumption is embedded in practices that are linked to the establishment and maintenance of effective household routine. In particular, energy consumption that promotes convenience in the operation of the household is likely to be practised even if it somewhat contradicts attitudes to saving energy or if it incurs costs. The study found that the priority given to convenience means that people will, on occasion:

- Use inefficient sources of heating;

- Use energy-consuming appliances even if alternatives are available;

- Allow their children to engage in high levels of energy and water consumption;

- Not switch appliances off at the point when not in use.

Contextual Factors and Personal Factors

Contextual factors can be described as factors that are beyond an individual's control (Stern 2000), such as access to information or resources (be that money, time or transport, etc). As such, these external factors are usually not included in social-psychological models, which only plot influencing factors that are situated in an individual's psyche. However, most models account for these contextual factors by incorporating them within the agency construct (e.g. Perceived Behavioural Control, (Ajzen, 1991)). The Theory of Interpersonal Behaviour features contextual factors in the construct 'facilitating conditions'; these are not simply external factors,

but include a person's ability to act, their state of arousal (e.g. hunger) and their knowledge of the behaviour. Contextual factors such as cost and the availability of information can be important in determining behaviour, but it should be noted these are not simply external, but also depend on how an individual perceives them.

Personal factors (attitudes, values, norms and habits) are rarely studied alongside contextual factors (physical infrastructure, technical facilities, availability of products, special product characteristics, advertising and shared socio-cultural objectives such as income and material growth) (Steg, 2008). The latter are likely to have a substantial impact on behaviour as they are likely to interact and contextual factors (e.g. available infrastructure, economic factors) are also important to acknowledge when they strongly inhibit or facilitate pro-environmental actions. Psychological motivations (and thus potentially informational interventions) are seen as relatively unimportant (Steg 2008). In exploring barriers to reducing energy use in homes, research shows that in some cases people indicate that they are not able to reduce their energy use. Some people are more restricted than others by contextual factors and despite a desire to carry out energy saving behaviour, these factors may prevent them from saving as much energy as another individual, with less interest and motivation in saving energy (Kaiser et al., 1999).

3.5.2 Interventions to Change Energy Use Behaviour

Psychological models of human behaviour traditionally inform strategies and models to change human behaviour. A number of techniques have been developed to change energy use in homes, and these interventions usually fall within the scope of psychological strategies. These tend to relate to the provision of information and advice, or fall within the scope of structural strategies, which often includes technical applications such as the introduction of energy saving infrastructure or technology (Steg, 2008). However, many of the existing structuring and reviews of intervention techniques are still based on the Applied Behaviour Analysis (ABA) approach, which differentiates mainly between antecedent and consequence strategies (see Geller, 1989; Dwyer et al., 1993; Abrahamse et al., 2005). This situation leads to problems, as Abrahamse et al. (2005), have put it:

> *"Most studies reveal only to what extent interventions have been successful, without providing insight into the reasons why"* (p. 283)

Depending on the specific behaviour to be changed and the particular context, some strategies are more effective than others. Importantly, a combination of interventions

tends to have a greater effect than any single approach, because they will influence the multiple drivers and barriers for change (Gardner and Stern, 2002). Generally speaking, behavioural interventions can be targeted at the individual, interpersonal or community, or structural levels (Halpern et al., 2004; Jackson, 2005) aiming to influence attitudes (change them to desirable attitudes or make desirable attitudes more conspicuous), norms (social or personal expectations of 'correct' behaviour) or broader opportunities and 'rules' for action. Interventions include informational (information campaigns, labelling, feedback etc), social (eliciting a verbal commitment, social comparison and support, etc), structural and economic approaches (market-based instruments, investment in infrastructure, regulation, etc) (Steg and Vlek, 2009).

Psychological strategies are aimed at changing people's knowledge, perceptions, motivations, cognitions and norms related to energy use and conservation. The assumption is that such changes will be followed by changes in behaviour and consequently by energy savings. Examples are the provision of information, education and modelling (Abrahamse et al., 2005). Structural strategies are aimed at changing the context in which decisions are made so as to make energy conservation more attractive. Structural interventions refer to interventions that work by altering one or more of the four conditions external to individual control, including accessibility, physical structure, social structure and media messages (Cohen et al, 2000). Examples are new or better products and services, changes in infrastructure, pricing policies and legal measures. These have been studied less frequently in psychology (Steg 2008).

Most psychological studies so far have focused on the effectiveness of Informational Interventions (psychological strategy), with limited studies looking at Technical Interventions (structural strategy) (Abrahamse et al., 2005; Steg, 2008), and no reference to both areas being researched in combination has been found.

Informational Interventions

Previous research on informational interventions indicate that they yield only modest behaviour changes (Steg, 2008) however, successful campaigns have included prompts (Luyben, 1982), individualised social marketing approaches in which information is tailored to the needs, wants and perceived barriers of individual segments of consumers (Abrahamse et al., 2007; Thøgerson, 2007); commitment

strategies (McKenzie-Mohr, 2000); eliciting implementation intentions in which people indicate how they plan to reduce their use (Bamberg, 2002); and modelling and providing information about the behaviour of others (Abrahamse et al., 2005). Other studies investigated the effects of information and various feedback types on the household energy consumption (Poortinga et al., 2003; Abrahamse et al., 2005). Assessments of smart meters (i.e. that show consumption clearly) show they can help lead to energy savings of 5-15% and there appears to be widespread public support for the technology and a clear preference for informational feedback in monetary terms (Whitmarsh et al, 2011b). Informational interventions are especially effective when pro-environmental behaviour is relatively convenient and not very costly in terms of money, time, effort or social disapproval, and when individuals do not face severe constraints on behaviour (Steg, 2008).

Research by Stenberg et al. (2009) evaluating 10 multidimensional refurbishment projects in Sweden, aiming to address social and environmental issues, has demonstrated the necessity of linking environmental and social aspects to gain long lasting impacts and gain a comprehensive overview. The research highlighted that changes in technical systems need to be accompanied with information for the tenants. The introduction of technologies and economic incentives triggered a learning process in tenants with regards to environmental and energy use behaviour. However, housing companies had not planned for a learning process to take place and as organisations, failed to learn from employees and tenants involved in the projects. Also tenants' organisations and other social networks did not plan for how they could become involved in organisational learning as part of the projects.

Of particular relevance for this PhD research perspective, Stenberg et al. (2009) found that by linking the study of social and environmental aspects this resulted in an extension and broadening of understanding by revealing interesting and complex interconnections between the two aspects. For example, organisational learning was a factor which prompted the authors to question the potential for environmental refurbishment projects to contribute to sustainable development. Actors such as housing organisations and other social networks (such as tenants' organisations), failed to focus on the process perspective, (i.e. planning how organisational learning is to take place, and knowledge to be maintained for future activities).

3.5.2.1   Technical Interventions

Structural strategies (which include Technical Interventions), are studied less frequently in psychology with studies typically focusing on perceived effectiveness of such strategies, and most focus on the effects of transport pricing and some on the introduction of energy efficient appliances (Steg, 2008). To date, with few exceptions (e.g. Poortinga et al., 2003), research generally focuses either on the influence of psychological and social factors on the acceptability of energy saving measures (Steg, 2008). Poortinga et al. (2003) have investigated the influence of physical and technical characteristics of energy efficiency measures on their acceptance to residents. Studies have also focused on the complexity of decision making in adopting physical energy saving measures (van Oel et al., 2009).

Another structural strategy technical intervention is to promote the adoption of energy efficient appliances (Midden et al., 2007). However, side effects of energy efficient appliances such as rebound effects may occur, when people use energy efficient appliances more often, because they *are* energy efficient (Hertwich, 2005). Rebound effects may also occur as a result financial savings made following a Technical Intervention, to use more energy or buy more products which consume more electricity (such as large TV screens), thus potentially negating energy savings, cost savings or carbon reduction from the Technical Intervention.

It is recognised in the literature that physical and technical energy saving measures imply behaviour changes, not only because occupants also need to accept and understand them, but they need to buy and to use them in the proper way (Steg and Vlek, 2009). Regarding interaction with technology with respect to conservation of natural resources, a review of literature by Midden et al. (2007), notes that technology and behaviour are closely interwoven in many respects. The work describes various ways in which technological and behavioural factors can be integrated in interactive approaches to effectively promote energy conservation. Midden et al. (2007) identified four main roles that technology plays:

(1) As intermediary. As an intermediary, technology stands between the behaviour an individual carries out to reach a certain goal, and the use of natural resources on the way to that goal;

(2) as amplifier. Where technology serves as an amplifier, takes a different perspective on the linkage between behaviour and the use of natural resources. Here the distinction is that the consumer has chosen a technology that clearly

enhances, extends, or amplifies his or her goal attainment. As a side effect, behaviour becomes progressively more resource-consumptive as well. Thus, the amplifier role creates the basis for rebound effects, where efficiency gains are dissolved due to amplified consumption;

(3) as determinant. Technology as a determinant can be viewed as that which directly influences our environmental behaviour. It is contextual technology that surrounds us, and can either help or hinder conservation-related actions, but we might not even notice this. Technology in the role of a determinant is about channelling or shaping behaviour apart from people's motivation. The availability of a car, for example, makes its use more likely, while the absence of it obstructs use drastically;

(4) *as promoter of environmentally significant behaviour.* Technology that is specifically designed to promote behavioural choices leading to the conservation of natural resources, differs from determinant technology in its emphasis on the motivation of the user. Technology that promotes conservation behaviour can come in several forms such as norm-activating litter receptacles, electronic appliances that allow the user to set a conservation goal and receive feedback.

The Midden et al. (2007) review concludes that scientists can contribute considerably to reducing environmental impact by analysing human behaviour and technology in parallel, and adds that well-designed technical environments, systems, and products have a great potential for supporting environmentally sustainable behaviour. This is particularly relevant to this PhD research due to its aim to evaluate the impact of retrofit technologies on tenant behaviour related to energy use, with an intention that findings from the research may contribute towards efforts to improve the design and application of retrofit programmes.

3.6 Conclusions

Household occupants' behaviour related to energy use can influence energy consumption and carbon emissions from buildings and homes. According to the same rationale behaviour related to energy use may impact on the energy saving potential of energy efficiency retrofits, contributing to energy saving potential or reducing energy saving potential.

Much of the literature attempting to explain or understand human action or activities discussed was based in the psychology literature, (in social psychology and

environmental psychology) and mainly based around psychological theories of behaviour. Related literatures of Practice Theory from the paradigm of sociology were discussed, but psychology is particularly dominant in the mainstream literature of understanding (and applying interventions to change) human behaviour, including behaviour related to energy use. Thus, psychological theories of behaviour and how these apply more specifically to the household occupants' behaviour related to energy use, were more prominent in this literature review.

Psychological theories of behaviour have a tenancy to focus on the role of attitudes and intention in determining behaviour. Although the literature has highlighted the significant correspondence between attitudes and behaviour, attitudes only occasionally guide behaviour, and most commonly this is where attitudes are strong and where social and structural condition support action. Principally, the key message emphasised in the literature is that attitudes do not necessarily predict behaviours, and thus changing attitudes (for example, through Informational Interventions) does not necessarily lead to behaviour change.

Five models and theories of behaviour change are most relevant in the literature to this research: the 'Rational-Choice Model', and attitude-behaviour models; the 'Theory of Planned Behaviour'; 'Theory of Interpersonal Behaviour'; 'Attitude-Behaviour-Context Model', and; 'The Needs, Opportunity and Ability Model'. The former three are intention-based models, the latter two models attempt to include external factors which may influence individual behaviour.

Practice Theory represents a contrasting insight into 'behaviours' in comparison with of psychological theories of behaviours, observing from the societal level rather than the individual level. 'Practices' rather than 'behaviours' are formulated by the ongoing interaction between 'structure' (as 'rules and resources') and 'discursive and practical consciousness' (as 'lifestyles'). A practice is formed through the integration of three elements 'materials' (objects), 'image' (conventions), and 'competence' (procedure and skills). These elements when integrated form a practice, which may then be sustained or broken if the links between elements are not sustained. Practices are complex and elements circulate, 'bundle', fragment and stabilise. Practices are formed from elements which are not only determined by the structure of society, but also determine shape the structure of society through their formation as practices. Psychology and Practice Theory are from different backgrounds and have contrasting approaches and perspectives. Nevertheless, this

thesis argues that if the distinctiveness of the approaches and empirical incompatibilities are recognised both disciplines can work towards sustainability problems in parallel.

The psychology literature emphasises that deliberation or reasoning has a minimal role in much behaviour, especially when it becomes habit. Habit can be distinguished from repeated behaviour as it is unconsciously conducted behaviour that is automatic. With regards to habits, conventional communication approaches to change behaviour will have minimal impact. Thus habits need to be disrupted either by individuals making specific plans to carry out alternative actions or by using (or creating) changes in the environment in which individuals act, in order to force individuals to reconsider their behaviour options. The literature also indicates there is not enough insight in the origin, the development, and the function of habits within the social context of a household.

With regard to factors influencing energy use behaviour of household occupants the psychology literature emphasises cognitive factors or social processes. Energy use is mainly driven by factors that are economic (e.g. cost), structural (e.g. location of home, size of home) and social factors (i.e. status, identity), environmental values have little influence. Behaviours are not on the whole financially driven or rational. For individuals to conduct energy conserving behaviours they must be aware of the need to reduce household energy use, be motivated to conserve energy use, and should be able to adopt the relevant behaviours.

The psychology literature highlights the complexity of changing behaviour and notes that regardless of a person's environmental concerns, there are likely to be multiple reasons for a 'choice' of behaviour or an individual may not even 'choose' a course of action at all. There may be multiple reasons for 'choosing' or engaging in behaviour such as cost, time, convenience and social convention. Thermal comfort in a home, and Contextual Factors (physical infrastructure, technical facilities) and Personal Factors (attitudes, values, norms and habits) can also influence behaviour. The literature highlights that regardless of the historical link between technology and the consumption of resources, technology is often set apart from behaviour in this context. This indicates that technology and consumption behaviours require further investigation.

Interventions deployed to change behaviour to conserve energy are, in psychology, based around Informational Interventions (e.g. provision of information or feedback) and Technical Interventions (e.g. better products or services or changes in infrastructure). Most psychological studies so far have focused on the effectiveness of Informational Interventions, with limited studies looking at Technical Interventions, and no reference to both areas being researched in combination has been found.

It is important to note that a significant proportion of the literature on energy use and behaviour has the premise of changing behaviour to be more sustainable or encouraging pro-environmental behaviour. That is encouraging a change in lifestyles in order to reduce the amount of consumption of resources including energy. The focus of this thesis is on the considering behaviours related to energy use in the context of an energy efficient retrofit in order to reduce energy use and carbon emissions, and there is indeed environmental or sustainability principles behind the main rationale for the research. However, this approach may not apply where energy efficiency improvements are desirable primarily for the sake of financial savings and thermal comfort, against a backdrop of low household income and cold homes. Changing behaviours for the sake of the environment or sustainability may be less relevant in these cases.

4. Research Methodology

4.1   Introduction

This PhD research aimed to evaluate the impacts of retrofit technologies and written and verbal guidance on tenant behaviours related to energy use, and to identify behaviour-related barriers to retrofit energy saving effectiveness. By evaluating a retrofit project in 'real-time', and from a social perspective, the findings are intended to inform Social Landlords conducting similar projects in the future, and to inform Government Policy related to the energy efficient retrofit of existing housing.

In the context of retrofit project implementation in a social housing context, this PhD research aimed to:

- Evaluate the impacts of retrofit technologies on tenant behaviours related to energy use.

- Evaluate the impacts of written and verbal guidance on energy saving behaviours.

- Identify behaviour-related barriers to retrofit energy saving effectiveness.

The research objectives were to:

- Gather baseline data on tenant behaviour related to energy use:
    - Before the Technical Intervention
    - Before the Informational Intervention

- Gather follow-up data on tenant behaviour related to energy use:
    - After the Technical Intervention
    - After the Informational Intervention

- Analyse and compare baseline and follow-up data to determine impacts on behaviour and identify behaviour-related barriers to retrofit energy saving effectiveness.

The approach to research design and the subsequent methodology are described in this chapter. The remainder of this chapter is split into six sections: an outline of the PhD research context (4.2), and approach to research design and methodology, due to the particular context of the research (4.3), description of interventions evaluated by the research (4.4) and a discussion of data collection methods (4.5), data analysis methods (4.6), and conclusions (4.7).

The purpose of this chapter is to explain how and why the research design and methodology was chosen in order to meet the dynamic context of the research situation, involving an external organisation and participants. The organisational requirements of the Social Landlord, Gentoo Group, necessitated data collection very early in the research process, with many research parameters being beyond the researcher's control due to Gentoo Group's existing agenda and operations.

In the first month of the PhD an 'Initial Research Framework' was developed to lay the foundations of the research design and allow data collection to begin only six weeks after PhD commencement. The 'Initial Research Framework' was developed in consultation with Gentoo Group and based around the organisation's 'Retrofit Reality' project objectives. Therefore, in order to conduct research in accordance with Gentoo Group's requirements, an inductive approach was required, underpinned by a qualitative research design. Considerations of research philosophy and theoretical perspectives were addressed as part the ongoing inductive approach to the research. Researcher positionality, viewed as an important aspect to this research was also considered as part of the 'Initial Research Framework' and reflected upon during the research process.

Semi-structured interviews, to allow tenants to express their day to day behaviours related to energy use, were carried out as a 'baseline' before, and 'follow-up' after the 'Technical Intervention' (retrofit technologies) and 'Informational intervention' (written and verbal guidance on energy saving behaviour) had been undertaken. These interviews were recorded digitally and transcribed for analysis of the texts. Data collection was based around '*a priori*' themes which formed the basis of the interview structure and the 'template' for subsequent analysis of the data.

The 'Initial Research Framework' allowed a broad qualitative dataset to be gathered allowing for ongoing phases of synthesis and analysis in the research process. An early analysis of data for Gentoo Group requirements, in March 2010, helped to decide on suitable data for later PhD research analysis and formulate a more effective approach to data analysis. Methods for data management and analysis were explored and developed as part of this 'Early Data Analysis', including the decision to use Computer Assisted Qualitative Data Analysis Software (CADAS).

Template analysis allowed the exploration and comparison of 'coded' data gathered from 'baseline' and 'follow-up' interviews, and thus patterns of changing energy use behaviour were identified, in the context of the retrofit project. Comparisons could also be made between the group that received 'Informational Intervention 2' (written and verbal guidance on energy-saving behaviour) and the group that did not receive this intervention. Importantly, the rich dataset combined with template analysis also allowed patterns of behaviour related to energy use, to be identified, which along with cross reference to the literature indicate why particular behaviours may have occurred or did not occur. A process of further analysis of the patterns identified highlighted 'key patterns', some of which were found to be present across energy use 'template themes'. This supported the proposed conclusions of 'Technical' and 'Informational' impacts on behaviour related energy use, and behaviour-related barriers to effective energy efficient retrofits. These conclusions can provide useful information to Social Landlords, and policy makers and indicate future areas for research that focuses on behavioural factors in the UK low-carbon housing strategy.

This chapter now describes the approach to research design and methodology in detail and explores the implications of combining these approaches and methodologies in this research.

4.2   PhD Research Context

The PhD research context, involving the collaboration with Gentoo Group in order to research the impact of a 'live' retrofit project on energy use behaviours in the field, had a significant impact on the research design, philosophical approach and methodology deployed. It is important, therefore to first outline 'Retrofit Reality', the project being implemented by Gentoo Group, before moving on to describe the methodological implications of undertaking the research to meet the requirement of this specific project.

4.2.1   The Retrofit Reality Project

Gentoo Group

The 'Retrofit Reality' Project is the context in which this PhD research was undertaken. Retrofit Reality was conducted by Gentoo Group, an organisation based in Sunderland, which is made up of a group of companies which formed a fraternal association, in 2001. Gentoo Group was established after the Large Scale Voluntary Transfer of Sunderland City Council's housing stock, some 36,000 homes. Initially called Sunderland Housing Group, the Group rebranded to become Gentoo Group in 2007 to assist its expansion into other local authority areas. The Companies that make up Gentoo Group are:

▪ **Gentoo Group Living** - a company based on generating the solutions to the challenges people and places face in order to bring about that community. By promoting independence and enterprise, the company aims to deliver opportunities community building and ownership, using methods such as; Care and support services, Community Empowerment programmes, Respect and Anti Social Behaviour programmes and Construction Challenge which offers construction skills to 15 and 16 year olds.

▪ **Gentoo Group Homes** - the house building division and development arm of the Gentoo Group which provides new homes for sale.

▪ **Gentoo Group Ventures** - is a company providing a comprehensive range of property solutions to partners and customers. Services include; land acquisition and site assembly; development; facilities management and leasehold management.

▪ **Gentoo Group Construction** – is the design and build business of the Gentoo Group, providing the following services; refurbishment works; new build housing;

development projects; maintenance; minor works, and; surveying and consultancy services.

- **Gentoo Group Sunderland** - is the Housing Association of the Gentoo Group, responsible for delivering core housing management services and maintenance to approximately 70,000 customers in 30,000 homes.

Retrofit Reality was managed by **Gentoo Group Green**, the sustainability directorate, which is situated at the group level of the organisation and is not a company. The project also involved contributions from Gentoo Group Construction and Gentoo Group Sunderland.

The Retrofit Reality Project

The Retrofit Reality project aimed to establish the 'reality' of the situation for landlords, customers and product suppliers when attempting to retrofit existing housing with energy efficient and low carbon technologies. The project intended to learn lessons for the sector through intensive research into the best solutions for existing stock in terms of cost, quality, availability, installation, future maintenance and user compatibility. Gentoo Group allocated funds of £255,000 to the project and secured £100,000 part sponsorship from the Tenant Services Authority (previously managed by the Housing Corporation before functions were transferred to the Tenant Service Authority) and a further £17,073 from the Low Carbon Building Programme.

An environmental consultancy undertook work for Gentoo Group to identify the best energy efficient solutions for the stock. Gentoo Group worked with the University of Northumbria, funding two PhD students for a three year period to assist with the technical aspects of low-carbon technologies and tenant behavioural aspects related the retrofit project.

Retrofit Reality Project Aims

The project aimed to retrofit 140 properties with various energy efficient and low-carbon solutions. Additionally it aimed to improve the performance standards score of the involved housing stock through modelling assessment, such as the Standard Assessment Procedure (SAP) and Energy Performance Certificates (EPCs).

Retrofit Reality Objectives and Outcomes

Gentoo Group's objectives were to overcome the technological, economic and behavioural challenges which make installing retrofit options difficult by:

- *"Discovering the best procurement methodology, getting the best value for money and obtaining the best service.*

- *Reducing price but improving quality, as lack of activity in this area can suppress supply, making costs repellent.*

- *Significantly improved speed and ease of the service delivery and installation process by the end of the scheme.*

- *Determine which type of intervention style initiates behavioural change whilst also maximising the technology utilisation.*

- *Collation of real data on the effectiveness of the solutions rather than relying on theoretical assumptions for carbon and customer savings. Ensuring that the solutions are not prejudicial to people on low incomes or who have special needs."* (Gentoo, 2008b, p.1)

The outcomes of the project are as follows:

- *"Suppliers and Installers of microgenerational technology will have a greater understanding of the needs, capabilities, demands of the market. They will be able to tailor their business to suit the needs and aspirations of the sector. Thus developing a competitive edge within the industry which allows access to value for money and improved service delivery whilst also fulfilling consumer demand.*

  - *Measures- Time, Price and Customer Satisfaction*

- *Through working with the supply chain to procure the best value we will set a benchmark for others in the industry.*

  - *Measures- Procurement Club and Service Level*

- *Establish which behavioural changes maximise the potential to reduce carbon emissions.*

  - *Measures- PhD work*

- *Improved knowledge for stock holders and owners of the suitability of products.*

  - *Measures- Report 'The Knowledge'*

Other outcomes of the scheme should see the refinement of sustainable procurement methodology, whilst establishing best value sustainable technological solutions on the market, taking into account cost and carbon savings. The results should then help inform Gentoo's future investment decisions and provide a similar insight to other organisations." (Gentoo Group, 2008b, p. 2)

Aspects Evaluated by the PhD Research

In the first weeks of the PhD research in October 2008, consultations were held with Gentoo Group to clarify how the PhD research could assist the organisation in meeting its objective related to behaviour change. This process contributed to the 'Initial Research Framework' (4.2.2) which directed research design and methodology. An approach was agreed with Gentoo Group, which would meet the organisation's objective for the Retrofit Reality project, through the PhD research. Thus the aims and objectives of the PhD research (see 4.1) corresponded with Gentoo Group's requirements to meet its objectives for the Retrofit Reality project.

Gentoo Group had to complete the Retrofit Reality project 18 months into the PhD research, thus they considered an 'Early Data Analysis' sufficient to meet their objectives and report was submitted to Gentoo Group in March 2010. The PhD research continued after this point and conducted a more comprehensive analysis which will be submitted to Gentoo Group after the PhD thesis completion.

Collaboration and Retrofit Reality Impact on Research Design

The time-frame of this PhD research was 3 years (September 2008 – September 2011). The time-frame for the course of the researcher's collaboration with Gentoo Group on the Retrofit Reality project was 18 months (30th September 2008 – 30th March 2010). A planning phase for the Retrofit Reality project had been completed prior to the PhD research commencing, and installation of retrofit technologies began in November 2008. Thus the emphasis of the PhD research was focused on gathering data in the first instance, with less time available to conduct a comprehensive literature review and plan the research in its entirety.

Given this particular research context it was appropriate to use an inductive approach, underpinned by a qualitative research design. This decision was made as part of the development of the 'Initial Research Framework' which also gave attention to epistemological and theoretical perspectives. In the process of conducting the research and revisiting the data (partly through the 'Early Data Analysis'), specific research methods for analysis were then identified and used to refine the data and construct the PhD findings. Findings of this research are therefore understood from patterns observed strongly in the interpretation of behaviour change, by analysing tenant reported behaviour, in the context of the retrofit project.

The research design and methodology of the PhD research is now explained in detail, beginning with the first step in the process, the development of an 'Initial Research Framework'.

4.2.2 'Initial Research Framework'

Taking an inductive approach, did not mean that the data collection did not have a particular direction, or target. Although time was restricted, before data collection began an 'Initial Research Framework' was developed to guide the research design process and ensure that both Gentoo Group and PhD research requirements could be achieved.

The 'Initial Research Framework' was developed though consideration of the research problem, a literature review and discussions regarding Gentoo Group requirements. Several meetings with research colleagues and supervision staff were also conducted to develop and refine ideas. The 'Initial Research Framework' identified research aims and objectives and a broad research question: '*How does an energy efficient retrofit project impact on energy use and environmental behaviours?*' This in turn directed the approach to sampling, interventions and data collection. By the beginning of data collection in November 2008 it was agreed that the research design should be qualitative and inductive in its approach. The design of data collection methods took priority, but data analysis approaches were considered. Key elements of the framework which are described in more detail in the relevant sections are the approach to research design (4.3), interventions evaluated by the research (4.4), data collection methods (4.5) and data analysis methods (4.6).

The remainder of the development of the research framework and identification of methods for data analysis were developed in conjunction with the process of actually conducting the research. In this inductive research approach, observations were made first (data collection), then patterns were identified (data analysis), a tentative hypothesis was formulated to explore these ('key patterns' identified) and conclusions were developed (conclusions proposed). Thus the findings of this research have been produced through an empirical process, however the conclusions may raise more questions and theories for further research, rather than to give answers and test theory. Using an inductive approach with a qualitative research design highlights the flexibility required when conducting real-time

research in a policy environment, working with organisations delivering policy on the ground.

4.3   Approach to Research Design

4.3.1   Philosophical Approach to the Research

An Inductive Approach

A general paradigm of enquiry that underpins the scientific approach, consists of inductive discovery (induction) and deductive proof (deduction) (Grey, 2009). This research employed an inductive reasoning approach due to the given research context requiring immediate data gathering. Which can also be referred to as a 'bottom-up' approach. This is generally the reverse of a deductive approach, where the researcher establishes a hypothesis by using theory, a variety of data and information is collected by the researcher to confirm or reject the hypothesis to resolve the issue. This is also referred to as the 'top-down' approach (Trochim, 2006). Figure 12 shows a diagram highlighting the key stages of both approaches.

Figure 12: Deductive and Inductive Research

Deductive Research

Theory

Hypothesis

Observation

Confirmation

Inductive Research

Theory (or Conclusions)

Tentative Hypothesis

Pattern

Observation
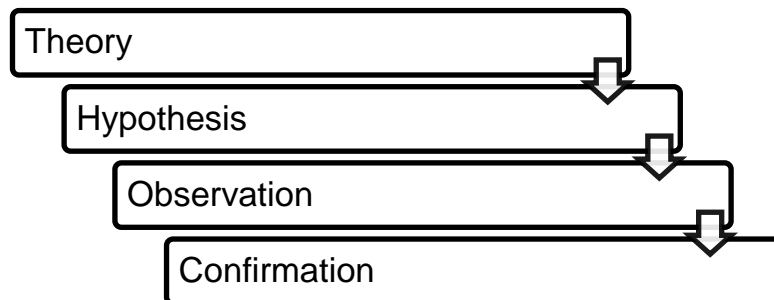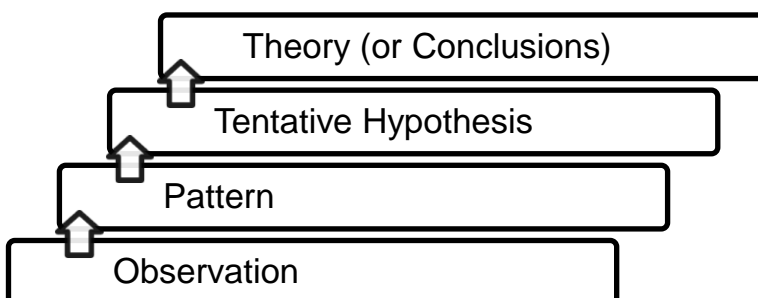
(Adapted from, Trochim, 2006)

Through induction, research moves towards discovering patterns and binding principles, while avoiding jumping to inferences or conclusions on the basis of data. To ensure a degree of reliability, a researcher often takes multiple cases or instances, though, for example multiplying observations rather than basing conclusions on one case (Gray, 2009). In this thesis patterns of energy use behaviour were observed based on a broad interview dataset, and conclusions were only drawn where these patterns were repeatedly observed.

Inductive research is a flexible approach because there is no requirement of pre-determined theory to collect data and information. The researcher uses observed data to reach at tentative hypothesis and define conclusions or a theory as per the research problem (Trochim, 2006). It would be incorrect to assume that the inductive process takes absolutely no note of pre-existing theories or ideas when approaching a research problem. The fact that the research problem has been raised as an issue for research, implies judgements about what is an important subject for research, and these choices are dependent on values and concepts (Gray, 2009). However, in taking an inductive approach this research does not set out to confirm or falsify a theory, but instead, through a process of gathering data, it attempts to establish patterns, consistencies and meanings.

This inductive approach is a backdrop to the qualitative research design. Classified according to purpose rather than design, this PhD research can be considered an interpretive study, as it seeks to explore people's experiences and their views or perspectives of these experiences. Interpretive studies are, typically, inductive in nature and often associated with qualitative approaches to data gathering and analysis. As part of the inductive approach this research considered methods for the analysis of data in part guided by the 'Early Data Analysis' (see 4.6.2), which was conducted.

Even though the context of this research necessitated an almost immediate start to data collection, it was important to consider the philosophical approach to the research (while developing the ''Initial Research Framework''), before immediately selecting a data gathering method and beginning the research.

Consideration of Epistemological and Theoretical Perspective

There are a range of theoretical perspectives and methodologies available to researchers, and according to Crotty (2003), these can sometimes carry terminology which is inconsistent or even contradictory. However, Crotty (2003) suggests that an interrelationship exists between the researcher's view of the epistemology, the theoretical stance adopted by the researcher and the methodology and methods used. Figure 13 shows a diagram as suggested by Crotty in '*The Foundations of Social Research'* (2003) which represent the categories of: Epistemology; Theoretical Perspective; Methodology, and; Methods, indicating their interrelationships. It positions one category after the other and then places some of the possible components in rows beneath each category. The rows beneath each category indicate relationships with each of the category by the general position in each row. For example, the epistemology of objectivism is related to the theoretical perspective of positivism, and a methodology of experimental research with methods of sampling.

Figure 13: Epistemology, theoretical perspectives, methodology and methods

Epistemology	Theoretical perspective	Methodology	Methods
Objectivism Constructionism Subjectivism (*and their variants*)	Positivism (and post-positivism) Interpretivism • Symbolic interactionism • Phenomenology • Hermeneutics Critical inquiry Feminism Postmodernism *etc.*	Experimental research Survey research Ethnography Phenomenological research Grounded theory Heuristic inquiry Action research Discourse analysis Feminist standpoint research *etc.*	Sampling Measurement and scaling Questionnaire Observation • participant • non-participant Interview Focus group Case study Life history Narrative Visual ethnographic methods Statistical analysis Data reduction Theme identification Comparative analysis Cognitive mapping Interpretative methods Document analysis Content analysis Conversation analysis *etc.*

(Crotty, 2003, p. 3)

It does not however appear to prescribe direct relationships as the complexities of the philosophical research perspective and process are likely to create some overlap between perspectives or methodologies and methods are not as directly informed by the researcher's epistemological position than methodologies (Willig, 2001). Nevertheless, the key point is that a relationship exists, and the researcher's epistemological stance will influence the theoretical perspectives adopted, which will then shape methodology and in turn method (Gray 2009). Therefore, the philosophical approach to the research required some consideration before embarking on data collection methods. Also, the debates on knowledge are often complex and controversial and form part of the search for truth in the ability to interpret reality. Consideration of the philosophical approach to the research is important in understanding the researcher's stance and context of the claims that they can make.

The aims and objectives of this research are to contribute to the understanding of behaviour related to energy use in the context of a social housing retrofit project. The research achieved this through a constructivist epistemology using an interpretive theoretical perspective. This allowed interpretation of behaviours related to energy use in the context of a social housing retrofit by focusing on the respondents' perceptions of their day to day experience. Constructivism allowed the building of conclusions based on these interpretations and interpretivism and constructivism align with the conditions of this quantitative and inductive research basis.

4.3.1.1   Constructivism

Objectivist epistemology holds that reality exists independently of consciousness, it suggests that there is an objective reality 'out there'. Research, therefore, is about discovering this objective truth. Closely linked to objectivism is the theoretical perspective of positivism. Contrasting this view is the constructivist epistemology which rejects this view of human knowledge. Truth and meaning do not exist in some external world, but are created by the subject's interactions with the world. Meaning is constructed, not discovered, so subjects construct their own meaning in different ways, even in relation to the same phenomenon (Gray, 2009).

According to Eastby-Smith et al. (2002), having an epistemological perspective is important for a number of reasons. It can help to clarify issues of research design,

not just in the design of research tools, but the overarching structure of the research including the kind of evidence that is being gathered, from where and how it is to be interpreted. Also, a knowledge of research philosophy helps the researcher to recognise which designs will work, to achieve particular objectives, and which will not.

4.3.1.2   Interpretivism

In terms of epistemology, interpretivism is closely linked to constructivism (Gray, 2009). Interpretivism is a theoretical perspective which asserts that there is no direct synergy between ourselves (subjects) and the world (object). The world is interpreted through the classification of schemas of the mind (Williams and May, 1996). Interpretivism puts forward the view that natural reality (and the laws of science) and social reality are different and therefore require different kinds of methods. While, on the one hand natural sciences are looking for consistencies in the data in order to deduce 'laws' (nomothetic), on the other hand the social sciences often deal with the actions of the individual (ideographic) (Gray, 2009). Crotty (2003) emphasises further:

> *"Our interest in the social world tends to focus exactly on those aspects that are unique, individual and qualitative, whereas our interest in the natural focuses on more abstract phenomena, that is, those exhibiting quantifiable, empirical regularities"* (p. 68)

As is often the case with other research, interpretivism is about understanding rather than explaining. It is held that it is possible to interpret the meanings and actions of actors according to their own subjective frame of reference (Williams, 2000). Interpretivism is concerned with the individual and qualitative aspects and this research takes an intepretivist stance by focusing on the tenant discussions of their behaviour related to energy use in the context of the retrofit project. There is an important distinction between the understanding and explaining roles of research (Crotty, 2003). Theorists, such as Dilthey (1833-1911), have suggested that the role of social science should be to 'understand', whilst natural science's focus is on 'explaining and causality' (Crotty, 2003).

It is not the focus of this research to explain the causality of energy use behaviours, but to understand changes in behaviour occurring in the context of the retrofit project. However, in the tradition of constructivism, this PhD research does build understanding and present conclusions by interpreting tenant verbalisations and explanations for their behaviour. These conclusions are put forward not as findings

of strict rules of causality, but as a basis for understanding behaviour related to energy use in this context and suggestions of areas of research to further interrogate such a phenomenon.

4.3.2 Qualitative Approach to Research Design

This PhD research used a qualitative research design to evaluate the impacts of a retrofit project on tenant's energy use behaviour. The research problem (acknowledging behaviour related to energy use in the effectiveness of energy efficient retrofit programmes), has a strong social focus and a qualitative approach allows an in-depth study of the phenomena relating to tenants day-to-day lives in a domestic setting. This allows events to be understood more adequately when they are observed in context and by the researchers immersing themselves in the setting. Qualitative research is the process of inquisition to understand a social problem and is often associated with interpretive and critical paradigms, though this is not always the case (Blaxter et al., 2006). This does not mean that qualitative research is not empirical; Shank (2002) defines qualitative research as:

> *"a form of systematic empirical inquiry into meaning"* (p. 5)

In this context '*systematic*' means 'planned, ordered and public', following rules agreed upon by members of the qualitative research community. '*Empirical*', means that this type of inquiry is grounded in the world of experience. '*Inquiry into meaning*' refers to researchers trying to understand how others make sense of their experience (Shank, 2002).

The qualitative researcher is required interpret the social phenomenon by using holistic design, analysis of human expression, citing views from informants in a natural setting (Denzin and Lincoln, 2000). Qualitative methodology is specifically designed to clarify the meanings of social situations and focus upon the way different people experience, interpret and structure their lives (Burgess, 1984). Such an approach captures data on the perceptions of actors in the field of study, therefore the research must be attentive, suspending preconceptions about a subject and being empathetic to those being studied. The focus of the research is therefore not just on the field setting but also the researcher's role within it (Gray, 2009).

Qualitative researchers criticise quantitative researchers because they claim objectivity, however statistical correlations may be based on 'variables' which are arbitrarily defined by the researchers themselves. Also, analysis of the meaning of quantitative correlations may involve common-sense reasoning or speculation. This emphasises the point that all research is selective and depends on collecting particular sorts of evidence through the 'lens' of particular methods (Mays, 1995) and regardless of methodological controls in quantitative research, the researcher's personal interests, and the influence of their social and cultural backgrounds is difficult to avoid (Flick, 2006).

Bazeley (2004) has argued that qualitative and quantitative approaches have been distinguished (and thereby defined) on the basis of the type of data used (textual or numeric; structured or unstructured), the logic employed (inductive or deductive), the type of investigation (exploratory or confirmatory), the method of analysis (interpretive or statistical), the approach to explanation (variance theory or process theory), and for some, on the basis of the presumed underlying paradigm (positivist or interpretive/critical; rationalistic or naturalistic). The decision here to use a qualitative research design had its basis not only in the inductive approach taken due to research circumstances, necessitating an exploratory approach, but also due to the research focus, being embedded in social aspects. Thus the researcher approached tenants as informants, through interviews in order to understand how they make sense of their experience of behaviour related to energy use. This meant that the research design, approach to data collection and ultimately analysis methodology would be qualitative. The research problem is associated with understanding how (and if) behaviour related to energy use is impacted by a retrofit project and a qualitative approach allows a more in-depth study of the phenomena relating to tenants day-to-day lives in a domestic setting. This allowed events to be understood more adequately when they are observed in context and by the researcher immersing themselves in the setting. Elements of subjectivity and tenant experience would not be fully captured if this research had taken a quantitative approach (Silverman, 2010).

Using a qualitative approach, tenants were given scope (through semi-structured interviews) to discuss their own behaviours and related reasoning for conducting such behaviours, in their own words. This allowed them to provide their perspectives through an interactive process in which the individual participants 'teach' the researcher about their lives.

The focus of this research was to understand *how* (and if) energy use behaviours are impacted by technical and informational interventions and explore some of the reasons *why* this occurred. Quantifying reported energy use behaviours can be relevant as it can indicate behaviour change patterns in a group of tenants. However, focusing on the question of *how many* behaviours related to energy use were being conducted (i.e. through quantitative research), would not have provided the in-depth understanding of the social aspects explaining behaviour. As a result of the closer researcher involvement, the researcher may find issues that are often missed by more positivistic quantitative enquiries.

Cherry (2000) argues that a qualitative exploratory research design is very useful when the researcher knows little about a group of people or phenomenon. This was of particular relevance given the context and timeframe of the research, as described above. Little was known about the particular group of people involved or the phenomenon of retrofit impacts on behaviour related to energy use. This exploratory qualitative design is also complemented by the way that qualitative research deals with the context, because as Burns (2000) argues, the contexts of qualitative inquiry are not designed, rather they are natural, and nothing is predefined or taken for granted.

The use of semi-structured interviews allowed the researcher to explore energy use behaviour in the context of the retrofit project, with the intention of including all material that was considered to be relevant to the research aims. This raises the important point of researcher positionality (discussed further in 4.3.3) whereby, among other factors, the consideration of what is deemed as relevant to the research focus and therefore captured in the data collection or analysis, is a subjective decision for the researcher.

Due to the inductive approach take here, 'findings' do not represent confirmations (or non-confirmations) of a particular theory or hypothesis. The main findings of this research are essentially theories developed through systematic observation of patterns in the data. When the same 'patterns of behaviour related to energy use', repeat in the same 'theme' or across different 'themes', these 'patterns' are then considered to be 'key patterns' (see section 4.6.3), and are then further discussed in relation to similar literature and conclusions formed (see chapter 5).

Acknowledging Quantitative Aspects of the Research

As part of the Retrofit Reality Project, Gentoo Group planned to measure energy consumption accurately, in order to measure changes in energy consumption before and after the Technical Intervention. This was primarily to observe the differences between relying on theoretical assumptions, such as the Standard Assessment Procedure, (SAP), and gathering actual energy consumption. However, due to unforeseen circumstances the gathering of data was extremely problematic. Various approaches to gathering the data were attempted by the researcher and Gentoo Group, such as contacting energy suppliers with written tenant permission to gather data and manual recording of meter readings both by the researcher and voluntarily by tenants, but there were complications with both approaches. The actual energy consumption data gathered was fragmented, only covering certain properties involved in the study and did not cover a sufficient time period and therefore was not considered reliable enough to conduct a useful analysis to correlate tenant behaviours related to energy use with energy consumption data. In addition the process of gathering data was time consuming, and considering the weaknesses in the data it was abandoned for a completely qualitative research design. SAP data was also rejected due to unreliability based on its assumptions (energy is not recorded but modelled based on the house structures and other aspects), thus the assumptions would not indicate changes in actual energy consumption, arising from behaviour change.

It is acknowledged that combining accurate quantitative measures of energy consumption, with a qualitative approach may have been useful for evaluating energy use behaviours. However, such an approach would require more planning time, a longer period of data recording perhaps three or more years, to cover variations in winter energy use due to prevailing temperatures, accurate energy recording equipment in each household and significant statistical analysis.

4.3.3 Researcher Reflexivity and Positionality

As part of a qualitative approach, it is important to note aspects of researcher positionality and reflexivity by describing these in relation to this research.

Positionality

Positionality is the practice of a researcher defining their own position in relation to the study, with the implication that this position may influence aspects of the study, such as the types of information collected, or the way in which it is interpreted (Salzman 2002). Positionality has been criticised as using general characteristics, such as gender, religion, class, or race, that may or may not say much about the actual perspective of any particular individual (Salzman 2002). Others such as Robertson (2002) argue for the usefulness of positionality stating that:

> *"Family history, ethnicity, sexuality, disability, and religion, among other distinctions, can be usefully woven into an ethnographic narrative, but only if they are not left self-evident as essentialized qualities that are magically synonymous with self-consciousness, or, for that matter, with intellectual engagement and theoretical rigour. Their usefulness must be articulated and demonstrated because such distinctions are not fixed points but emerge and shift in the contiguous processes of doing and writing about fieldwork."* (p. 790)

Therefore Robertson argues that positionality is only useful if one's position is reflected upon, and articulated with respect to its influence in terms of research fieldwork. In this PhD research the role of the researcher was acknowledged as one of the interventions being researched. Thus it was acknowledged that impacts may have occurred from the presence of the researcher. The researcher may have influenced tenants because tenants may have felt they need to give a socially acceptable answer, and the association of the researcher with Gentoo Group may have had a similar impact. The researcher's role in providing verbal information as part of the interview process may have impacted tenant responses and this was acknowledged as 'Informational Intervention 1'. Tenants sometimes requested further information in order to understand the questions or discussed certain issues and asked questions, this may have influenced tenant's responses because they may not have had this information without the interaction with the researcher, thus may have answered the question differently. However, this aspect was unavoidable as tenants had to understand the questions and concepts they were discussing in order for them to discuss their behaviours related to energy use.

Reflexivity

Reflexivity is a concept used to describe the relationship between the researcher and the object of research (Brannick and Coghlan, 2007). It is mostly influenced by feminist researchers and those from hermeneutic and critical theory traditions (Gray, 2009), mainly in the collection of qualitative data, usually through interviewing (Ryan

and Golden, 2006). Reflexivity involves the realisation that the researcher is not a neutral observer, and is implicated in the construction of knowledge. According to Coffey (1999), researchers need to be aware of how fieldwork data gathering and ethnographic writing construct, reproduce and implicate selves, relationships and personal identities. Many researchers fail to recognise this and in many accounts the researcher is invisible along with the social and institutional contexts (Mauthner and Doucet, 2003).

Gray (2009) points out two main forms of reflexivity. Through epistemological reflexivity the researcher reflects on their assumptions about the world and about the nature of knowledge. With personal reflexivity, in which the researcher reflects upon how the influence of their personal values, attitudes, beliefs and aims have served to shape the research. This may involve a personal reflection on how the research process impacted on and changed the stance taken by the researcher. Honesty and transparency are important in this approach which locates the researcher in the dynamic of the research process.

Mauthner and Doucet (2003) have noted that research methods on practical steps to reflexivity are limited, but some approaches include: designing research with multiple investigators, encouraging dialogue and critical exchange of ideas; writing a reflexive journal, and; reporting research perspectives in research reports (Gray, 2003). According to Weber (2003) there are potential problems with reflexivity, arguing that narcissism can create such self-introspection in the researcher that it becomes the actual focus of study. The researcher is so conscious of the limitations, constraints of the research, the assumptions and biases that underlie the work they become paralysed. Grey (2009) points out that these warnings are appropriate, but are likely to be aimed at the more extreme margins of the reflexivity movement, and for other researchers reflexivity should be embraced to the extent that it is in line with attitudes towards epistemology and principles of research design and practice.

Empathetic Inquiry

Qualitative social research relies on empathy with the people studied for understanding particular phenomenon. Empathy is different from sympathy, which is a feeling of personal closeness, endearment and a feeling of emotional accord. It would be unrealistic to assume that empathy and sympathy will not occasionally co-exist, but a majority of researchers try to be empathetic rather than sympathetic (Stake, 2010). Due to the immersion of the researcher in the phenomenon being

studied qualitative research has been described as 'connected knowing' (Candib, 1995). According to Stake (2010):

> *"Connected knowing is the embodiment of empathy, using personal experiences and relationships to inquire how others see how things work. It relies on a studied perception of situations in context, thus working toward creditability and esteem."* (p. 47)

Empathetic inquiry relates to feminist approaches, which will be further discussed below, however it also connects with the concept of '*verstehen'*, a German word, which has the same meaning in English as 'understand', but also in the context of the social sciences refers to 'empathetic insight' (Bhaskar, 1989). 'Verstehen' is an experiential understanding of action and context introduced by the German Philosopher, Wilhelm Dilthey, who argued that knowledge in the human sciences is greatly different than in the physical sciences, the latter being impersonal explanations of how things work, the former being what humans think and feel as to how things work (Stake, 2010). 'Verstehen' essentially relates to understanding the meaning of action from the actor's point of view and adopting a research stance which treats the actor as a subject, rather than an object of observation. Unlike objects in the natural world human actors are not simply the product of the pulls and pushes of external forces, individuals are seen to create the world by organising their own understanding of it and giving it meaning. When conducting research involving tenants it is therefore important to consider 'empathetic enquiry' and take into account the meanings that they attribute to their actions and environment.

Feminist Approaches

This section will discuss the features that shape and define what is meant by feminist research, followed by an explanation of how it applies to this research. Any research process involves an on-going series of decisions and choices. Methodologically, feminist research differs from traditional research for three reasons: It actively seeks to remove the power imbalance between research and subject; it is politically motivated and has a major role in changing social inequality; and it begins with the standpoints and experiences of women (Brayton, 1997).

First, the unequal power relationship between the researcher and the subject is restructured to validate the perspective of the participant. The premise is to remove the hierarchical relationship between researcher and participant. Changing research terminology from one of hierarchy to one of equality is the first step. Many authors talk about the use of 'participant' as a preferred term to the use instead of 'subject'

or 'researched'. However, addressing the imbalance in power relations between researched and researched is more than simply changing the language of research. Changing the power relationship would entail involving the participants at all levels of the research process (Brayton, 1997).

Recognising the participants as the experts and authorities on their own experiences is taken as the starting point for research. Participants are part of the social world and as critical thinkers are also conscious and aware of the patterns of social relationships that can impact upon their own lived realities. While the standard within traditional social science research is to see the research as 'owned' by the researcher, feminist research that seeks to restructure inequality also seeks to remove the notion of ownership of knowledge (Wolf, 1996). Maintaining the originality and authenticity of how the participants give meaning to their experiences is also part of what constitutes changing the power imbalance in feminist research (Brayton, 1997).

Recognising the researcher as part of the research process also constitutes changing the power relation between the researcher and the participant. The social location of the researcher (e.g. age, race, orientation, class) plays a role in shaping the research process. It is important for the researcher to identify their own location in order to address biases that may result from their own location in the social world (Brayton, 1997). The frameworks of the researcher's understanding need to be critically examined, to look for tensions and contradictions that they may entail (Lather, 1988). The researcher is as much an active agent in the world as the participant and acknowledging individual agency is important to restructuring the power relationship. The choices being made by the researcher are shaped and motivated by social location, from the choice of a research topic to decisions on how to present the material.

Feminist approaches are relevant to this PhD research, because it attempts to remove the hierarchical relationships between the researcher and tenant by using relaxed and neutral interview terminology. The PhD research recognises tenants as experts and authorities on their own experiences and the researcher attempted to maintain authenticity when interpreting how participants' give meaning to their experience. The researcher aimed to record, interpret and understand tenant experiences from an open neutral perspective and attempting to 'take nothing for granted'.

4.4   Interventions Evaluated by the Research

For the purpose of this research the term 'intervention' refers to an action or process of intervening in order to reduce energy consumption, to sustained lower levels prior to intervention, without impacting adversely on thermal comfort. The following sections describe the various interventions being evaluated as part of this PhD research.

4.4.1   Technical Intervention

The Technical Intervention was the retrofit of homes by Gentoo Group. It involved the installation of a series of technologies (see table 7) which aimed to improve the energy efficiency of the building and reduce carbon emissions. The Technical Intervention changed the fabric of tenants' homes, and introduced new heating and control systems and other technologies. This altered accessibility, physical structure and individual control, and thus are considered (in psychology) to be a type of 'structural intervention', therefore for the purpose of this research the retrofit technologies are collectively termed the 'Technical Intervention'.

The Technical Intervention was designed by Gentoo Group with the assistance of an external consultant. Therefore the researcher had no control over the types of technologies deployed or the timing of their installation, due Gentoo Group already having plans in place. Although all technologies installed had the aim of improving energy efficiency it was not clear what the exact reasons were for specific technologies deployed. Table 7 lists the technologies which were in the 139 involved properties before the technical intervention and after the technical intervention.

Table 7: Technologies in properties before and after the Technical Intervention

Pre Retrofit	Post-Retrofit
Single Glazing	Double glazing (sample of argon-filled double glazing)
Single Glazed Wood Doors	Double glazed PVC doors
Bath only (with occasional electric showers)	Mains-fed showers
Back boiler systems with hot water tank	A-rated combi-boilers with new heating system
Gas fires	Electric Fires

4.4.2 Informational Interventions

Generally it is the aim of Informational Interventions to encourage behaviours related to energy use that are conservative of energy, without compromising thermal comfort. This differs from the retrofit measures, which aim to change the energy efficiency of the fabric of the building (e.g. double glazing) and integral technologies (e.g. A-rated combi-boiler) which use energy.

To support the Retrofit Reality Project aims, Informational Interventions (known as a part of a 'psychological strategy') were introduced to the Retrofit Reality project as part of the PhD research. For the purposes of this research Informational Interventions are considered interventions by means of written or verbal communication which provide information on behaviour related to energy use or associated information (e.g. climate change, environmental behaviour).

There are two Informational Interventions, 'Informational Intervention 1' is the intervention which arose from the researcher interacting with tenants and was only provided verbally. It was more general in scope and covered a range of subjects related to energy use and environmental issues, and was also more flexible dependent on the questions or discussions which occurred with tenants. 'Informational Intervention 2' is written and verbal guidance on energy saving behaviours, which is more specific to behaviour related to energy use and is provided in written and verbal form at a separate date to interviews.

Informational interventions may impact on tenant energy saving behaviours as a result of the dissemination of information through various methods such as face-to-face advice. It was suggested by the Housing Corporation in *'Fit for the Future: The Green Homes Retrofit Manual Technical Supplement'* (2008), that a tenant who is informed on energy saving behaviours will be more likely to apply this knowledge to daily behaviours. The Housing Corporation (2008) recommended that:

- Advice was to be targeted when tenant's personal circumstances change, for example advice related to heating systems is particularly effective when a new heating system is installed and/or major energy efficiency improvements are made.

- The most effective delivery mechanism for energy advice is that given, face-to-face (verbally), preferably in the home. This enables interaction and discussion,

which help to establish what advice the tenant really needs and allows for demonstration of technologies.

▪ Advice should always be backed up with appropriate written material.

The Housing Corporation (2008) also expressed interest in further research into the application of energy advice according to these recommendations. Gentoo Group was also aware of the recommendations put forward by the Housing Corporation and wanted to test the recommendations as part of the PhD research. The following Informational Interventions were deployed as part of the PhD research.

Informational Intervention 1: Researcher Information

All tenants involved in the research took part in semi-structured interviews undertaken by the researcher. This provided the opportunity for tenants to discuss their experiences of the Technical Intervention and their related energy consumption behaviours. This inevitably involved a two way discussion, where tenants asked questions to understand information, or may have been informed by the content of the questions. This face to face, interaction is considered an informational intervention as it has the potential to inform tenants on behaviours related to use and related issues through this communication.

Informational Intervention 2: Written and Verbal Guidance on Energy-Saving Behaviours

An information booklet (see appendix 1) aimed to provide tenants with written guidance on energy-saving behaviours and took into account the new retrofit technologies installed. It was designed by the researcher, based on similar information disseminated by other Social Landlords and cross checked with information from the Energy Saving Trust (EST, 2009) to ensure the correct advice was included. Gentoo Group reviewed the booklet to ensure it was accessible as part of their customer communication policy. The booklet acts as a reference on energy saving advice and reinforces the verbal guidance on energy-saving behaviours provided upon issue.

Upon issue of the written advice the researcher described the information outlined in the booklet in order to deliver the informational intervention in a verbal manner, communicating face-to-face. This provided tenants with a variation on communication type and this may have suited tenants with a preference for verbal

communication. The delivery of the booklet verbally may also reinforce messages upon later reading of the booklet, or if tenants do not decide to read the booklet they are still provided with the information verbally. The written and verbal guidance was provided to 13 of the tenants involved in the research, and the sampling was determined partly by preference for information, by random selection and by tenant availability. Follow up interviews queried the effectiveness of the written and verbal guidance as an informational intervention and if it impacted on behaviours, by asking the tenants questions. As discussed in the next section which describes the data collection methods in detail.

4.5   Data Collection Methods

Before discussing methods further it is important to clarify terminology used in the remainder of the thesis. The term 'tenant' is used to refer to the interviewee who is participating in the research. The term 'interviewee' may also be used to describe the participant of the research, this is mainly when discussing research methods. When describing the research findings the term 'tenant' is often used, however in broader discussion of occupant behaviour (i.e. which may refer to other occupiers other than the research participants), the term 'occupant' may be used. 'Researcher' is the term given to the person involved in conducting the PhD research in its entirety.

To monitor the daily behaviours of tenants by observation was considered impractical and infringed on tenant privacy. It was therefore decided that discussing issues with tenants themselves would be the most practical and reliable way to gather data considering the circumstances and time-frame. Thus to capture a range of data for future synthesis and analysis a broad interview framework was developed. This was based around various aspects of tenant knowledge, attitudes, behaviours and other issues related to the retrofitted energy saving technology. This semi-structured approach to interview allowed a broad range of subjects to be discussed including both the subject of energy consumption behaviours and wider environmental issues.

These interviews took place in one location in the same type of housing on two adjoining streets in High Ford, Sunderland in the North East of England. Interviews were conducted face-to-face and tenants were asked a series of questions, which structured the interview but allowed them to respond to a number of open ended

questions in their own words. The following sections explain the data collection process in detail.

4.5.1 Sampling Context

The Retrofit Reality Project involved a total of 139 properties in a number of locations in the Sunderland area. At the request of Gentoo Group, further interviews of the same format (baseline and follow up) including additional specific questions, were conducted with 10 tenants who had received solar thermal technology as part a retrofit in housing stock in Usworth, Washington. Also a further 6 interviews of the same format were conducted with tenants who had received electricity monitors as a technical intervention, in High Ford, Sunderland. Overall, a total of 51 tenants received interviews (51 baseline interviews and 51 for follow up interviews), as part of the research. However, data from the 10 tenants who had received solar thermal technology and data from the 6 tenants who had received electricity monitors was not included in the analysis. This was due to differences in the property types and technologies deployed as part of the Retrofit Realty project in those particular houses in comparison with the dataset used in the PhD research. Also, due to a lack of control over timing of the interventions for these 16 properties, interviews took place at different periods to the main sample group used in the PhD research. This difference in timing would have not offered a suitable comparison with the data set used for the PhD research because tenants had been exposed to the interventions for different lengths of times and to interviews at different times of the year (i.e. summer or winter).

For the location which was used in the research, Gentoo Group provided the researcher with a sample of 44 properties that received the Technical Intervention on two adjoining streets in High Ford, Sunderland. These 44 properties were selected by Gentoo Group in order to represent a range of household occupancy types and due to the similar design and specification of the properties. Household occupancy was demographically mixed, being made up of various ages and occupancy numbers from one person to large families. Gentoo Group used their Neighbourhood Assessment Matrix (NAM), a database which holds tenant and leaseholder details, gathered from customer surveys to provide tenant contact details to the researcher for the 44 properties. These details only provided one tenant name so in some cases other tenants of the same household would volunteer

for the interview on the day. Follow up interviews aimed to ensure that the same tenants were interviewed as those in the baseline interviews.

Of the sample of 44 properties provided by Gentoo Group 35, received baseline interviews and became part of the sample, based mainly on tenant availability. During follow up interviews it was only possible to interview 26 out of the 35 tenants due to tenant availability, including reasons such as illness, **thus the final sample comprised 26 tenants**. It is acknowledged that each tenant's lifestyle patterns which impact on their availability, may give rise to sample bias towards tenants who are only available through the day. Thus tenants in the sample may be more available during the hours of 9-5 pm and the sample may represent different energy use behaviours than a group who would be available only in the evenings. However in an attempt to mitigate this limitation numerous attempts were made to visit tenants, including evening visits, and phone calls and messages were left in order to arrange convenient appointments. Therefore all tenants were given an opportunity to take part in the interviews.

Location of Respondents

The following map (figure 14) shows the location of the households which were involved in the PhD research. The households were situated on two adjoining streets in High Ford, Sunderland in the North East of England, approximately 9 miles south east of Newcastle upon Tyne City Centre and 2 miles east of Sunderland City Centre. Their exact location has not been revealed to ensure confidentiality of the identity of tenants involved.

Figure 14: Location of Households involved in the Research

(Source: Google Maps™)

4.5.2 Ethical Considerations

Protecting the participant

Interviews were arranged with tenants in accordance with Gentoo Group's customer care policy. Gentoo Group provided tenants with information on the content of the project and what their involvement would entail, and tenants were informed that they could withdraw from interviews at any time and that all information gathered would be reported anonymously. Signed permission was obtained by Gentoo Group from tenants that wished to take part in the research including provisions for handling data with confidentiality, reporting data anonymously and consent to digitally record interviews. The document requesting signed permission from tenants also explained the research and highlighted that tenants could opt out of the research at any time. Verbal guidance on research and the nature of the interview was repeated at the beginning of each interview along with a further request to record the information digitally. In reporting findings, tenant data are handled anonymously and alias codes are used on quotations which cannot be traced back to individuals.

Protecting the researcher

As part of the selection process Gentoo Group confirmed that there was no previous record of violent conduct/intent in relation to the households involved in the research. Immediate colleagues and at least one supervisor were informed of the location of each interview, including the expected completion time. The interviewer was contactable throughout (i.e. by mobile telephone).

4.5.3 Interviews with tenants

An in-depth, semi-structured, face to face form of interview was employed. Questions were used to structure interviews based on a broad set of environmental or retrofit linked themes. The interview structure was developed by compiling a range of questions based on 'Environmental Knowledge', 'Environmental Attitudes', 'Environmental Behaviour', 'Appliances' and 'Tenant Satisfaction with their home', 'Energy and Water Consumption' (perceptions) and 'Health and Wellbeing' (see appendix 2 for a copy of the interview structure). The types of question were based on the same questions found in the DEFRA Report: '*Report, questionnaire and data tables following Survey of Public Attitudes and Behaviours toward the Environment: 2007*' (2007). Questions regarding energy use behaviours were based on suggested energy saving tips provided by the Energy Saving Trust website (EST, 2008). Based on these energy saving tips issued by the Energy Saving Trust questions were designed to gauge the interviewees response and thus what behaviours were being conducted with regard to energy use. Interviews were also structured to gather information on the impact of the Technical and Informational Interventions on tenant knowledge, attitudes and behaviours, through specific questions which were included in the follow up interviews. The broad set of themes in the interview structure in conjunction with a large number of interviews, created a reservoir of data for subsequent synthesis and analysis of 'baseline' and 'follow-up' datasets.

Tenants responded to questions verbally and were also given the opportunity to discuss issues surrounding each theme, such as related rationale for behaviour, opinions, attitudes and perceptions. Prompts or further questions were used to clarify responses or understand tenant reasons or context surrounding responses. The purpose of the interview was exploratory so as to achieve an in-depth understanding of tenant energy use behaviours and surrounding themes. The flexibility in interviews allowed the tenant to express narratives which were not originally targeted in the interview framework, thus allowing a wide range of

experience and perspectives to be captured. This approach in conjunction with the considerable length and number of interviews in two phases, captured a large body of raw data. The volume of data and range of themes compensated for limited time available for research design to target specific information, by allowing targeted data to be extracted at a later stage when research design had been refined. Also, Gentoo Group had interests in gathering certain information from interviews such as aspects relating to tenant environmental knowledge, environmental attitudes and general environmental behaviours. Some of this data was used in Gentoo Group's dissemination reports to the wider public (e.g. Gentoo Group, 2009). It is acknowledged that there are limitations to this approach, as tenants may not necessarily verbalise their actual behaviours. Nevertheless, the volume of interviews, along with a repeat of the same interview and acknowledgement of these limitations in the analysis, still provides considerable scope to offer credible contributions to knowledge.

Due to the restricted research schedule time was only permitted for a small number of pilot interviews, which were conducted with colleagues or friends. This helped to refine a number of questions and gauge the length of time required for interviews. Based on the pilots, interviews were scheduled to last 30 minutes to 45 minutes.

Interview Deployment

Interviews took place with 26 individual tenants each residing in their rented home. The interview schedule (i.e. when the interviews were arranged to take place) was based on the retrofit implementation designated by Gentoo Group. Retrofit installations (Technical Intervention) began in November 2008 and finished in early March 2009. Therefore baseline interviews took place in November and December 2008 and targeted households which had not yet been subject to Technical Intervention. The same individuals received follow up interviews approximately 12 months later (November and December 2009). These tenants were interviewed at approximately the same time of year 12 months later in an attempt to mitigate seasonal impacts on energy use, for example tenants utilising technology for space heating more in the winter and less in the summer. This 12 month time gap between interviews also allowed all tenants to adjust to the exposure of the Technical Intervention and allowed time for the researcher to deploy Informational Intervention 2: the written and verbal guidance on energy saving behaviour, to half of the total sample of 26 tenants.

Informational Intervention 2 was deployed in July and August 2009, leaving some time for tenants to adjust to Informational Intervention 2 before the follow up interviews. It is acknowledged that there may be limitations to the provision of written and verbal energy guidance during the summer months as tenants may not be as strongly motivated to save energy due to a reduced demand on space heating. However, due to the timescale of the project this was the only time at which Informational Intervention 2 could be deployed.

Recording Data

The semi-structured interviews asked the same questions of all the study's interviewees. Interviews typically involve individual interviewees, but sometimes other people (household, or non-household members) were present during the interview. Some of these other people involved themselves in the interview by delivering responses or discussing issues with the interviewee or researcher, but data is only recorded from the individual interviewee (tenant).

Informational Intervention 1: researcher information provided through interviews with tenants, can also be considered an Informational Intervention because there is potential for tenants to ask questions or become informed by questions and/or discussion related to the issues which are being researched. The influence of the researcher as an intervention, thus inherently affects the entire sample involved in the research.

It is important to note that the data gathered only reflects statements for one single interviewee per household and other energy users in the household may express different responses to the interview. Other non-interviewed household members may carry out different behaviours in the household and therefore could have more influence on energy use through these behaviours. For example, in the group of tenants involved in this study in the case of couples, women are often responsible for washing clothes and drying clothes, so a man being interviewed will ask women about this behaviour as they do not conduct these behaviours and thus do not have knowledge to answer the question. Questions also aimed to capture information on the tenants' perception of their general environmental behaviours or behaviours related to energy use.

The findings are representative of tenant verbal responses to interview questions or related discussion. However, these verbal responses may not reflect actual behaviours or changes in behaviours in reality. Actual behaviour may require further verification (e.g. through energy monitoring equipment) and this was beyond the scope of this research project. Although it is not possible to confirm that tenants' verbal responses reflect actual behaviours, the research questions were designed to observe inconsistencies in responses, where possible, by asking related questions or rephrased questions at other points in the interview. Part of the data analysis involved identification of likely reasons for changes or non-changes in behaviour, and this process also helps to identify the validity of verbal responses as other likely motivations for changing behaviour related to energy use that may not relate to verbalisations.

4.5.4 Transcriptions

All audio recordings of interviews were transcribed completely verbatim in order to minimise loss of data. External support was required in order to complete all transcriptions and conduct preliminary analysis for Gentoo Group's project requirements by the 30th March 2010. Funding was secured through National Energy Action (NEA) and the School of the Built and Natural Environment at Northumbria University to outsource a majority of the transcriptions to professional transcription services. It is acknowledged that there may have been a potential weakness in this part of the data analysis due to someone with minimal knowledge of the research conducting the transcriptions. In order to mitigate this weakness transcribers were asked to produce the text verbatim and key texts were compared with the audio playback of the interview by the researcher to check for errors. Transcriptions were recorded into electronic format using Microsoft Word and were then converted to, 'rich text format' for import to MAXQDA2007 software for coding.

4.6   Data Analysis Methods

There is a range of literature that documents the underlying assumptions and procedures associated with analysing qualitative data. Many of these are associated with specific approaches or traditions such as Grounded Theory (Strauss and Corbin, 1998), phenomenology (van Manen, 1990), discourse analysis (Potter and Wetherell, 1994) and narrative analysis (Leiblich, 1998). However some analytic approaches are 'generic' and not labelled with any of the specific traditions of qualitative research (Ezzy, 2002; Pope et al., 2000), one such approach is 'template analysis' which the data analysis method is largely based on.

4.6.1 Template Analysis

The term 'template analysis' does not refer to a prescribed method, rather it describes a varied but related group of techniques for thematically organising and analysing textual data. Essentially in template analysis the researcher produces a list of codes ('template') representing 'themes' identified in the textual data. Some of these will often be defined *'a priori'* (before data collection and analysis), but they will be modified and added to as the researcher reads and interprets the texts. The 'template' is organised in a way which represents the relationships between 'themes', as defined by the researcher, most commonly involving a hierarchical structure (King, 2004).

The data involved are usually interview transcripts, but may be any kind of textual data. Hierarchical coding is emphasised; that is to say, broad 'themes' (e.g. perceptions of energy costs) encompass successively narrower, more specific ones (e.g. costs are perceived very high, or very low, or average). Once any '*a priori'* 'themes' are defined, the first step of the analysis is to begin reading through the data, marking in some way any 'text segments' that appear to tell the researcher something of relevance to the research question. Where such 'text segments' correspond to '*a priori*' themes, they are 'coded' as such. Otherwise, new 'themes' are defined to include the relevant material and organised into an initial 'template'; normally this is done after initial 'coding' of a sub-set of the data – for example, after reading through and 'coding' the first three transcripts in a study. This initial 'template' is then applied to the whole data set, and modified in the light of careful consideration of each transcript. Once a final version is defined, and all transcripts have been 'coded' to it, the 'template' serves as the basis for the researcher's interpretation or illumination of the data set, and the writing-up of findings (King,

2004). Further detail of the technique and how it was applied in this PhD research can be found in the analysis section (4.6.3).

Reasons for Choosing Template Analysis

As discussed in earlier in the chapter (section 4.3.1) this PhD research is based in the epistemology of constructivism in the theoretical perspective of interpretivism. Template analysis may be used within a range of epistemological positions, including both positivist and interpretivist theoretical perspectives. Thus, template analysis is appropriate in this epistemological and theoretical context.

Major proponents a of template organising style have come from educational research, particularly the work of Miles and Huberman (1994). Much of the focus is on reducing the data through the coding process so they can be displayed in an explicit form for interpretation. Miles and Huberman (1994) are clear in their perspective

> *"that social phenomena exist not only in the mind but also in the objective world – and that for some lawful and reasonably stable relationships are to be found among them"* (p. 4)

They are concerned about transcending the historical, social, and meaning-making processes that lie at the centre of knowledge and phenomenological experience. Their aim is to construct (with care) explanations that can account for the process in plausible ways (Huberman and Miles, 1998). Therefore, they emphasise explanatory structure and careful, deliberate and explicit description. There are other reasons why template analysis was chosen as a data analysis method. There are a number of other approaches which resemble it such as Grounded Theory (Strauss and Corbin, 1998), which was originally considered and rejected in favour of template analysis. Grounded theory has been developed and utilised primarily as a realist methodology in the epistemology of objectivism, which was not suited to this PhD research approach (King, 2004). The data analysis method of template analysis aligned well with constructivist and interpretivist perspectives and has previously been used in research with these perspectives (Crabtree and Miller, 1999).

Template analysis was also chosen due to it being less time consuming than other methods such as 'Interpretive Phenomenological Analysis' (IPA). Like IPA, template analysis develops conceptual themes and their clustering into broader groupings and eventual identification of cross cases of 'master themes' with their subsidiary

'constituent themes'. However, IPA analyses individual cases in greater depth before attempting any integration of a full set of cases, and tends to be based on samples of 10 or fewer, whereas template analysis can comfortably handle larger samples with 20 to 30 being typical. Template analysis works particularly well when the aim is to compare textual data of different groups of people within a specific context (King, 2004).

The template organising style has several advantages that make it an attractive approach in the interpretive process. Making the code manual and coding text is relatively quick, reproducible, and easy to grasp for those sceptical about qualitative research. However, when used alone, there is potential for missing information, especially if the code manual is produced in a completely '*a priori*' manner. The interpreter also runs the risk of not looking beyond the codes. These concerns can be overcome by using multiple organising styles in different cycles through the iterative processes of analysis and interpretation (Crabtree and Miller, 1999). The procedure of template analysis can also come across as daunting to researchers, as Crabtree and Miller (1999), put it:

> *"The interpretation of a mountain of information-rich, purposefully sampled, qualitative text can easily appear insurmountable and quixotic, especially to researchers proficient in qualitative methods. This is reason enough to pause and briefly tremble"* (p. 177)

4.6.2 Early Data Analysis

At the request of Gentoo Group a report was submitted on initial findings of the research in May 2010 (see appendix 3). As a full analysis had not yet been completed, findings were based on anecdotal evidence based on notes gathered during interviews and by listening to interview recordings. These notes, based around the interview structure were read several times, themes were identified and trends were indicated by quantifying tenant responses. This 'Early Data Analysis' was particularly useful in considering the approach to more detailed analysis through coding the interview transcripts and identifying reliability of data and data suitable to address the research question: *How does an energy efficient retrofit impact on energy use behaviour, and what is the role of written and verbal guidance on energy saving behaviour?*

'Early Data Analysis' raised further sub-questions, such as: *What is the role of retrofit quality in its impact on energy use behaviour?* To be targeted for further investigation in later phases of analysis. This aided the inductive process, allowing further tentative hypotheses to develop for further analysis. The 'Early Data Analysis' also helped to refine the specific 'themes' to be included in the later analysis 'template'. Data that was considered unreliable (e.g. due to badly phrased and unclear questions), or not specific to the research question (e.g. opinions on environmental issues) was excluded from later analysis. Robust patterns in the data were also identified for further detailed analysis. Importantly, the 'Early Data Analysis' allowed the direction of analysis methodology to be better defined. It became clear that a thematic approach was required due to the multifaceted nature of the data. Also due to the way data was collected and the approach of comparing baseline and follow up interviews, it was clear that template analysis would be a useful data analysis method.

4.6.3 Data Analysis Method

After interview data was collected in the form of digitally recorded audio and then transcribed, for the purpose of analysis these can be referred to as texts or textual data. The technique of template analysis was used to identify 'patterns of behaviour related to energy use'. Texts had to be coded utilising software tools for synthesis and analysis, before deriving 'patterns of behaviour related to energy use' and where these were frequently identified recurring across or within 'template themes' – 'key patterns' (of behaviour related to energy use). These 'key patterns' were then the subject of discussion in the context of the literature (see section 5.4) out of which conclusions were put forward. To assist the description of the data analysis process described further below figure 15 shows a summary of the process.

Figure 15: Summary of the Data Analysis Process

Defining the Themes and Codes
- Based on interview structure 'themes' and 'codes' are defined
- Basic 'template' constructed using MAXQDA software

Coding the Data
- Using MAXQDA software text segments assigned to 'codes' within 'themes'
- 'Template' adapts and develops based on tenant responses to form an eventual analysis 'template' after coding completion

Analysing the Data
- MAXQDA software allows text retrieval of coded texts in specific 'themes' or datasets for observation of groups of texts
- Comparisons are made between baseline and follow-up data and between specifc datasets to idenfity 'patterns'

Synthesis of Patterns
- Reoccuring 'patterns' across 'themes' in the 'template' identified as 'key patterns' through a synthesis process
- 'Key patterns' are considered stronger in validity due to their reoccurance within 'themes' but also across different 'themes'

Conclusions
- 'Key patterns' are discussed in detail in relation to the literature
- Conclusions are put forward

Defining the Themes and Codes

The general analytical approach adopted, largely followed the conventions of template analysis, as it involved the development of a coding 'template', which summarises 'themes' identified from the textual data (King, 2004).The 'template' is made up of 'themes' and 'codes'. Themes are features of a tenant's account of experiences that the researcher sees as relevant to the research. In the case of this research the 'themes' were already identified in the research design and formed the interview structure. A 'code' is a label attached to a section of text to index it as relating to a 'theme' or issue which the researcher identifies as important. The 'themes' and 'codes' in this research are based on the interview structure devised as part of the 'Initial Research Framework'. Therefore a 'theme' normally refers to a particular behaviour question or topic (e.g. switching off appliances completely when not in use), and 'codes' refer to tenant responses relating to that question or topic (e.g. tenants' forget to switch off appliances completely when not in use).

These initial 'themes' in the 'template' are usually referred to as '*a priori'* themes, because the research has started with the assumption that certain aspects of the phenomenon under investigation should be focused upon (King, 2004). These 'themes' and 'codes' based on the interview structure formed a basic 'template' to be adapted and further developed later in the coding process (see 'coding the data' below). MAXQDA 2007 textual analysis software was used to build the basic 'template' and manage all textual data, it also acted as a tool to allow the coding and retrieval of text segments indexed to specific 'themes'.

MAXQDA 2007 is Computer Assisted Qualitative Data Analysis Software (CAQDAS) which supports researchers performing qualitative data analysis by aiding the systematic evaluation and interpretation of texts (such as interview transcriptions). MAXQDA 2007 is used in a wide range of academic and non-academic disciplines, such as in Sociology, Political Science, Psychology, Public Health, Anthropology, Education, Marketing, Economics and Urban Planning.

Like other CAQDAS packages MAXQDA 2007 software helps to make order out of qualitative data, with tools to manage the recorded complexity, allowing the structuring and interpretation of the data (Schönfelder, 2011). Therefore, the primary functions of CAQDAS packages have been described as storing, managing, and analysing (Jackson, 2003). However, it is important to emphasise that CAQDAS packages such as MAXQDA 2007, do not perform qualitative analysis, but they

provide a variety of tools to support a researcher conducting it (MacMillan, 2005; Seale, 2010). CAQDAS packages like MAXQDA 2007 are particularly useful when handling larger volumes of textual data such as the data that was gathered as part of this research as it allows for better data management and access through text coding and retrieval processes.

Coding the Data

The MAXQDA 2007 software enabled 'coding', where text segments were associated with particular 'themes' and 'codes'. The interview structure (see appendix 2) provided a basis for the coding 'template', whereby interview questions or topics were assigned as a 'theme', and tenant responses to questions in the transcription were assigned as 'codes' or 'sub-codes' depending on the responses delivered. See figure 16 for a sample of the 'template' in MAXQDA 2007 showing 'themes' and 'codes', figure 17, for a text segment associated with this 'theme' and 'code', and see appendix 4 for the full analysis 'template'. Tenant responses which fell outside the interview structure were recorded as new 'themes', 'codes' or 'sub-codes' and assigned accordingly. For example, respondents sometimes reported reasons for behaviour change or other information such as barriers to behaviour change, which was coded and contributed to the analysis.

Figure 16: Sample of the template showing themes and codes
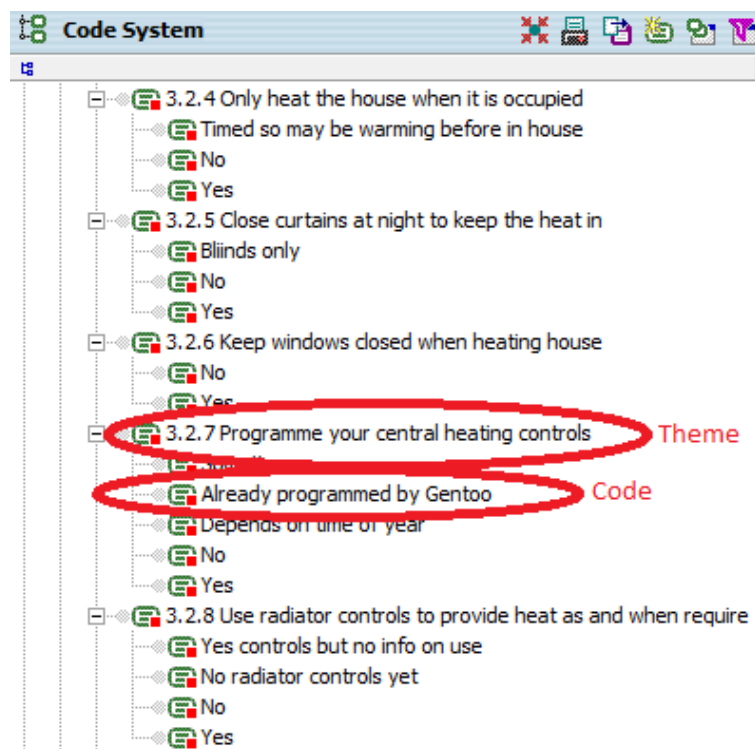
Figure 17: Retrieved text segment associated with the above theme and code
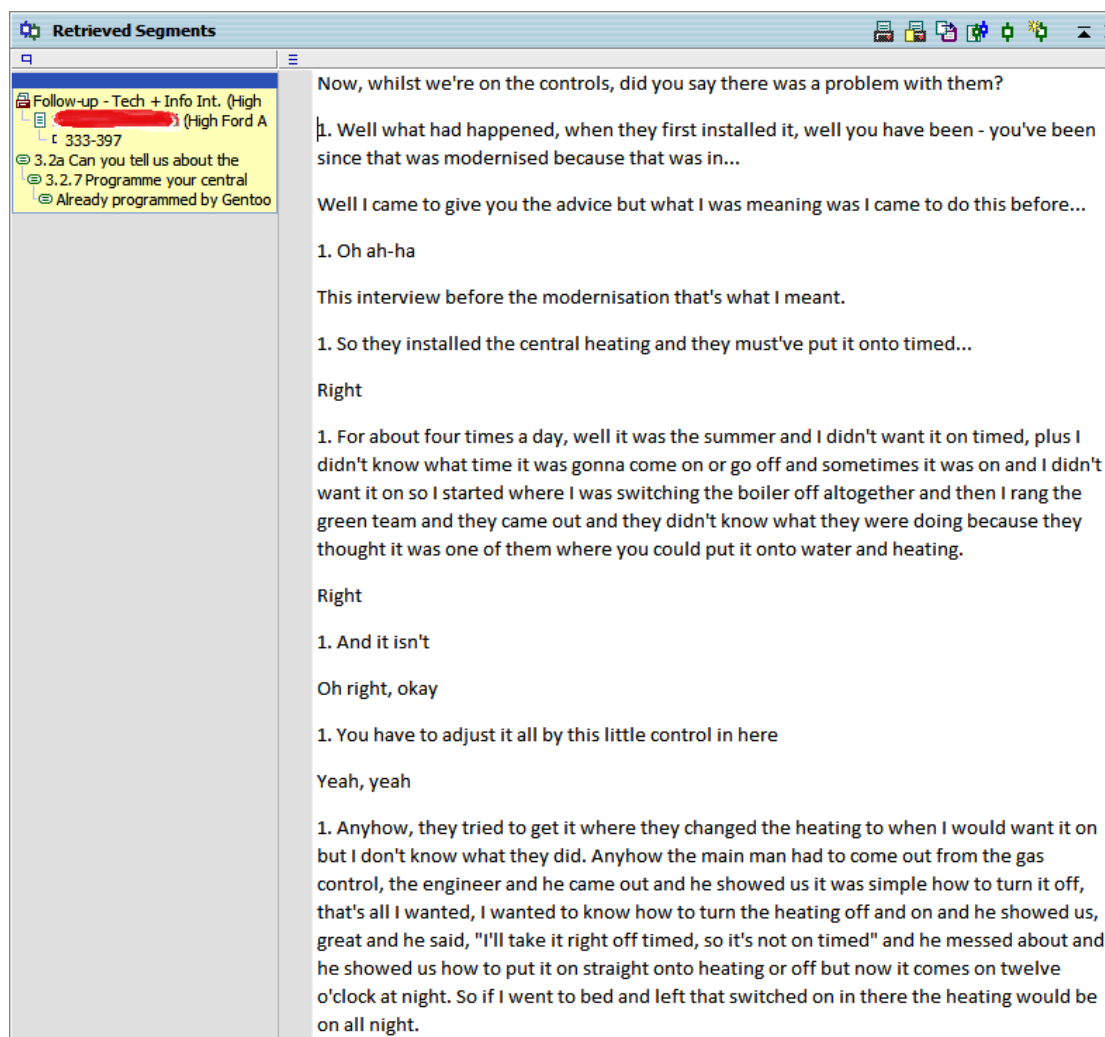
During the coding process the researcher read through the texts and based on tenant responses to questions or other comments, assigned these 'text segments' to a relevant 'code' within a 'theme'. If the tenant response did not closely resemble an existing 'code' or 'sub-code', a new 'code' was created to represent this response. This process allowed for tenant responses to influence the 'template' and thus, allow data to be gathered more flexibly based on the circumstances that tenants are reporting and this complements the inductive and interpretive nature of this research. This is relevant as the project time-frame prevented a scoping exercise to clearly identify lines of enquiry, which would form a more targeted 'template' for analysis. This research methodology therefore allowed particular issues to be raised by the target audience which were captured in the data where they may be otherwise lost in a deductive approach with specifically assigned boundaries to the coding of responses. As the same interview structure and questions were applied in the baseline and follow up interviews, comparisons could be made between

responses in both interviews. This was achieved in MAXQDA 2007 by retrieving coded text segments.

Analysing the Data

After all texts had been coded, it was possible to use the 'template' to retrieve particular segments of text from the dataset. This allowed a large number of responses from particular tenants assigned to a particular 'code' or 'sub-codes' to be viewed immediately on screen for observation. This function was used to identify 'patterns of behaviour related to energy use' in regard to particular 'themes'. The term 'pattern' in this research relates to an occurrence which repeats within a 'theme' or across 'themes'. Part of the process of identifying 'patterns of behaviour related to energy use' was to retrieve numerous 'text segments' across all interview data for observation. Particular 'codes' could also be used to compare texts from different interviews. Therefore comparisons of tenant responses between the sample group exposed to Informational Intervention 2 and the sample group that was not, were conducted. Also, baseline and follow up interviews were compared in reference to 'themes' and 'codes' relevant to behaviour related to energy use.

Some of the questions based on behaviour related to energy use required quantifying the number of tenants giving a particular response. This provided the basis of comparison between behaviours related to energy use before the interventions and after the interventions associated with particular 'themes'. If a number of tenants report the same behaviour related to energy use and then this number of tenants reporting this behaviour related to energy use, changes, this helps to indicate a pattern in the data. Other tenant responses may repeat in the data, such as reasons for conducting such behaviour or not conducting such behaviour. These responses can also assist the interpretation of the data and identify other patterns such as the reasons for particular changes in energy use behaviour.

An impact on energy use behaviour was considered to be 'significant' if evidenced in one fifth or 20% tenants within the group (6 tenants of 26) or within a sub group (3 tenants of 13). This particular threshold was chosen because it was a large enough proportion of tenants to indicate a change in behaviour, but not too small a proportion to indicate changes due to slight variation arising regardless of intervention.

Patterns observed within each theme (or question topic) were then synthesised further in order to identify 'key patterns', as explained further below.

Synthesis of Patterns

As a further step in the analysis, recurring 'patterns of behaviour related to energy use' identified within and across the 'themes' in the 'template' (or 'template themes') were synthesised in order to identify 'key patterns'. This was achieved by listing all 'patterns of behaviour related to energy use' identified by the data analysis in a matrix under each 'theme'. By observing all the 'patterns of behaviour related to energy use' together in relation to 'themes' it was possible to identify recurring patterns, considered 'key patterns', and which 'themes' particular patterns are associated with. This required the interpretation of the 'patterns of behaviour related to energy use' and consideration of what 'key pattern' they closely represent. These relationships are illustrated in the 'Core Findings Matrix' (section 5.3.3). Due to their recurrence not only within but also across 'template themes', these 'key patterns' are considered stronger in validity as findings. Thus through further discussion in relation to the literature (5.4) these can then form the basis for conclusions to be proposed (5.5).

4.7   Conclusions

The specific PhD research context of collaboration with Gentoo Group in order to research the impact of a 'live' retrofit project had major implications for the philosophical and methodological approach, subsequently impacting on research design and methods. In this particular research context is was appropriate to use an inductive reasoning approach to the research, underpinned by a qualitative design, within suitable epistemological and theoretical perspectives, all of which were considered as part the 'Initial Research Framework'. A framework put forward in the first month of the PhD research to guide the research process in this particular case of almost immediate data collection.

The decision to use a qualitative research design had its basis not only in the inductive approach taken due to research circumstances, necessitating an exploratory approach, but also due to the research focus, being embedded in social aspects. Thus the researcher approached tenants as informants, through interviews in order to understand how they make sense of their experience of energy use

behaviour. This meant that the research design, approach to data collection and ultimately analysis methodology would be qualitative.

This PhD research did initially attempt to utilise quantitative data to reinforce and verify the qualitative data, however due to unforeseen circumstances the gathering of data was problematic. Various approaches to gathering the data were attempted by the researcher and Gentoo Group, but the process was time consuming and the actual energy consumption data gathered was fragmented, only covering certain properties involved in the study and did not cover a sufficient time period and therefore was not considered reliable enough to conduct a useful analysis.

Template analysis was favoured because it aligned with the constructivist epistemological approach of the research and the interpretivist theoretical perspective. Template analysis was also suited to sample sizes similar to that conducted in this research. 'Early Data Analysis' raised further sub-questions to be targeted for further investigation in later phases of analysis. This aided the inductive process inherent to the research design, buy allowing further tentative hypotheses to be developed for further analysis. Using a data analysis process based on template analysis identified 'patterns of behaviour related to energy use' which were subject to further synthesis to identify 'key patterns' (of behaviour related to energy use). The following chapter describes and discusses the findings of the PhD research, including such 'patterns of behaviour related to energy use', and 'key patterns'.

5. Findings and Discussion

5.1   Introduction

This chapter describes and evaluates the findings of this PhD research and proposes conclusions. The focus is on the impact of the Technical Intervention and Informational Interventions deployed as part of the Retrofit Reality project on tenant behaviour related to energy use. The sequence in which this chapter is presented reflects the nature of the methodological approach, containing the following sections:

▪   Patterns of behaviour related to energy use (5.2)

▪   Identification of Key Patterns (5.3)

▪   Discussion of Key Patterns (5.4)

▪   Conclusions (5.5)

Firstly in section 5.2, a detailed description of the findings based on the 'template themes' is set out, followed by a brief discussion for each 'theme'. 'Themes' are organised under five main titles: Motivations and General Behaviour Related to Energy Use (5.2.1); Space and Water Heating (5.2.2); Controlling Drafts and Maintaining Thermal Comfort (5.2.3); Electrical Appliances and Lighting (5.2.4), and Other Impacts of the Interventions (5.2.5).In section 5.3, a summary of all the core findings shows the relationship between 'interventions', 'themes' (interview topics)

'patterns' of behaviour related to energy use and shows the 'key patterns' which occur across themes. In   section 5.4, the 'key patterns' are discussed in detail reflecting on the literature, conclusions are then put forward in relation to the findings.

5.2   Patterns of Behaviour Related to Energy Use

This section describes changes in behaviour related to energy use occurring within 'themes' (based on questions asked in the interviews). It describes tenant reported differences between behaviour related to energy use at the baseline (before interventions) and at follow-up (after interventions). Then for each of these 'themes', changes in behaviour related to energy use are discussed and 'patterns of behaviour related to energy use' are presented and summarised at the end of each 'theme'. Each sub-section outlines notes on the context of the interview questions where relevant, and a description and a discussion on potential causality based on tenant statements.

5.2.1 Motivations and General Behaviour Related to Energy Use

5.2.1.1   Reported Motivations for Energy Saving Behaviour

The following tables indicate tenants' reported motivations to save energy, focusing on money saving motivation, and motivation to help the environment.

Context

In baseline interviews tenants were asked if they 'agree strongly'; 'agree'; 'disagree'; or; 'disagree strongly', with the following statements; 1) 'I would like to reduce my energy use in order to save money' (table 8), and; 2) 'I would like to reduce my energy use to help the environment' (table 9). In an attempt to distinguish the priority between the motivation of saving money and the motivation of helping the environment, 8 of the 26 were asked (during baseline interviews) what was the primary motivation to reducing energy use is, i.e. to save money or to help the environment (table 10).

Table 8: Tenant responses to money motivation question

I would like to reduce my energy use in order to save money				
Sample Group	Strongly Agree	Agree	Disagree	Disagree Strongly
All tenants (baseline)	7 (27%)	19 (73%)	0	0

Table 9: Tenant responses to environmental motivation question

I would like to reduce my energy use to help the environment				
Sample Group	Strongly Agree	Agree	Disagree	Disagree Strongly
All tenants (baseline)	5 (19%)	21 (81%)	0	0

Table 10: Tenant responses to primary motivation question

Which is the priority out of the two; saving money or helping the environment?			
Sample Group	Saving Money	Helping the Environment	Depends on Situation
8 of 26 tenants (baseline)	6 (75%)	1 (13%)	1 (13%)

Description

All tenants 'agreed' or 'strongly agreed' that they are motivated to save energy in order to save money, or help the environment. In comparison between table 8 and table 9, more tenants (8%) strongly agree that they would like to reduce energy use in order to save money, than to help the environment. When a sample of tenants were asked which is most important, a majority of tenants (75%) stated that money was the priority.

The one tenant that could not prioritise between saving money and helping the environment stated that this was dependent on the financial savings versus the environmental impacts in a given situation. When responding to the question in table 10, the tenant stated that their primary motivation to reduce energy use depended on the relative amount of money savings available versus potential to help the environment, where higher potential savings of money will trump the priority of environmental consideration:

> *"...to me you've got to be talking about a considerable amount, i.e. somebody says oh you'll be saving a hundred pound a week...I think everybody would [prioritise saving money], but if it's a case of, oh you're only saving a pound a week, but you're saving a pound a week [sic], but you're gonna be saving more in the environment wise" (89FRB).*

Discussion

Considering the above findings it is clear that all tenants express motivations to save energy in order to save money and for the sake of the environment. However, further investigation of the qualitative data reveals an overall priority for saving energy in order to save money. Impacts on finances due to energy consumption (and resulting fuel costs), appear to be more relevant to tenants than the negative environmental consequences associated with energy consumption. If a tenant increases energy consumption, increased costs will be incurred for fuel consumption and this has a direct impact on tenant finances, and thus, is relevant to the tenant. However the increased energy consumption would also increase associated environmental impacts. Perhaps there is no direct impact perceived on the tenant which makes the issue less relevant and of no immediate concern. Therefore the principle motivation to save energy is to minimise costs in the context of restricted budgets. A tenant responding to the question in table 10 helps to illustrate this:

> *"I would [prioritise helping the environment] but it all depends on your situation...If you've got the money yes...It's cos of the money problem it's not - you don't think about the environment...I don't think many people do now, it's cos there's too much on to keep warm" (270SLB).*

Patterns of Behaviour Related to Energy Use

- Tenants report that their primary motivation to save energy is to save money, but are also motivated to save energy to help minimise environmental impacts.

5.2.1.2   General Gas and Electricity Consumption Behaviour

These findings indicate tenant reported changes in behaviour related to energy use as a result of the Technical Intervention and Informational Intervention 2 (written and verbal guidance on energy saving behaviours), in addition to behaviour change regarding general gas and electricity consumption.

Table 11: Gas Consumption Behaviour Change

Do you carry out actions to cut down on your gas use in your home?						
	Before Technical Intervention and Informational Intervention 2			After Technical Intervention and Informational Intervention 2		
Sample Group	Frequent	Occasional	Never / Very Rarely	Frequent	Occasional	Never / Very Rarely
Exposed to Informational Intervention 2	13 (100%)	0	0	13 (100%)	0	0
Not exposed to Informational Intervention 2	13 (100%)	0	0	13 (100%)	0	0
Total	26 (100%)	0	0	26 (100%)	0	0

Table 12: Electricity Consumption Behaviour Change

Do you carry out actions to cut down on your electricity use in your home?						
	Before Technical Intervention and Informational Intervention 2			After Technical Intervention and Informational Intervention 2		
Sample Group	Frequent	Occasional	Never / Very Rarely	Frequent	Occasional	Never / Very Rarely
Exposed to Informational Intervention 2	13 (100%)	0	0	13 (100%)	0	0
Not exposed to Informational Intervention 2	13 (100%)	0	0	13 (100%)	0	0
Total	26 (100%)	0	0	26 (100%)	0	0

Description

All tenants interviewed stated that they 'frequently' carry out behaviours to cut down on their gas use and electricity use. There was no change in the general behaviour relating to gas or electricity use as a result of the Technical Intervention or Informational Intervention 2.

As shown in both tables 11 and table 12, there is no significant difference in behaviour change between the group that was exposed to Informational Intervention 2 and the group that was not exposed to this intervention.

Discussion

The findings indicate that all tenants express that they conduct behaviours to minimise gas consumption and behaviours to minimise electricity consumption. The same response given by all tenants indicates that tenants in general express an attitude towards minimising energy use.

This reinforces the findings in section 5.2.1.1 which suggest tenants' motivation to save energy is to minimise costs. Also, out of 26 tenants interviewed, 17 check pre-payment meters or weekly budget methods for their heating bill (see 5.2.5.2) and therefore have a strong awareness of how much their fuel use costs day-to-day or week by week.

Behaviours are linked to this awareness of energy use and cost. For example tenants switch off combi-boilers manually (from hot water and heating standby) to minimise background use (keeping water warm) before switching on for short periods of heating or hot water use. This is supported by the literature which shows tenants are well aware of the link between energy use and costs and make attempts to minimise use to keep costs down.

Patterns of Behaviour Related to Energy Use

- All tenants conducted behaviours to conserve gas and electricity and there was no impact on behaviours as a result of the Technical Intervention or Informational Intervention 2.

5.2.1.3   Reported Behaviour Change Related to Energy Use

Context

In the follow up interviews, tenants were asked if their behaviour related to energy use had changed since the Technical Intervention and Informational Intervention 2 had been deployed. The three main categories were defined by the way tenants responded: stating that their behaviours had not changed 'no change in behaviour'; their behaviour had changed but in very little way 'slight change in behaviour', or; they reported that their behaviour had changed 'change in behaviour'. The below table (table 13) shows responses by tenants falling under these three categories.

Table 13: Reported Energy Use Behaviour Change

Do you think you behaviour relating to energy use has changed in any way since the modernisations [Technical Intervention]?			
Sample Group	No change in behaviour	Slight change in behaviour	Change in behaviour
Exposed to Informational Intervention 2	5 (38%)	6 (46%)	2 (15%)
Not exposed to Informational Intervention 2	10 (77%)	2 (15%)	1 (8%)
Total	15 (58%)	8 (31%)	3 (12%)

Description

Of the total, a majority of tenants (58%) reported 'no change in behaviour' since the Technical and Informational Intervention 2 were deployed. The remaining tenants reported a 'slight change in behaviour' (31%) and a minority (12%), a 'change in behaviour'.

There is a significant difference between reported behaviour change between the sample group that exposed to Informational Intervention 2 and the group that was not exposed to Informational Intervention 2. More tenants in the former group reported behaviour change, with higher numbers of tenants reporting 'slight change in behaviour' (46%) and 'change in behaviour' (15%), than the group that was not exposed to Informational Intervention 2.

Discussion

The results suggest that Informational Intervention 2 had an impact and created a change in behaviour (or tenants perceived a changed behaviour), in that sample group. However, there could be other explanations why this pattern occurred.

Firstly, the patterns observed could be related to sampling, as the group exposed to Informational Intervention 2, expressed interest in receiving the information (based on baseline interviews) and accepted the intervention delivery. Due to this existing predisposition towards the Informational Intervention 2, tenants may have engaged more with Informational Intervention 2 (or indeed engaged more with the Technical Intervention and Informational Intervention 1), and this therefore had more impact on their actual (or perceived) behaviours related to energy use.

More tenants may have reported behaviour change after receiving Informational Intervention 2, due to biases in the way people report their views, such as social

desirability (see Literature review, section 3.2.1). In this case, a tenant has been exposed to Informational Intervention 2, which they accepted as part of their involvement in the Retrofit Reality project. As Informational Intervention 2 was a focus of the question asked and the Informational Intervention was deployed by the researcher (who also was conducting the interviews), some tenants may have stated that Informational Intervention 2 had an impact because it was the socially acceptable response in this situation. It is also worth considering that the tenants are likely to have associated the researcher with Gentoo Group. This may also have influenced tenant responses as they sought to provide acceptable responses to the organisation that is providing the Technical Intervention.

Tenants' behaviour may have been influenced by other information related influences, such as the media information or information provided by energy suppliers, possibly contributing to any changes in behaviour reported. Other outside influences may be friends and family, or changes may be due to other motivations, such as saving money (see section 5.2.1.1), as a result of financial pressure and/or a coincidental increase in pro-activeness to save money. During the research period (and beyond) the UK was experiencing an economic depression and tenants reported impacts as a result of this, such as losing employment though redundancy.

It is interesting to note that more than half of the tenants interviewed stated that they have had no change in behaviour, even though they reported specific changes in behaviours related to retrofit technologies after the interventions. This indicates that tenants may not be conscious of their changing behaviours and that their statements may not necessarily match their actual behaviours. Changed behaviours may have become habit and driven by unconscious processes, rather than by conscious deliberation.

Patterns of Behaviour Related to Energy Use

- A majority of tenants reported no change in energy use behaviour (this suggests that tenants are not consciously aware of, or deliberate their energy use behaviours).

- Significantly more tenants reported changes in behaviour in the group that was exposed to Informational Intervention 2.

5.2.2 Space and Water Heating

5.2.2.1   Programming Central Heating Controls

Context

As part of the Technical Intervention a number of tenants had their central heating control facility pre-programmed. This was either programmed by Gentoo Group, contractors working for Gentoo Group, or installed with programmed factory settings. If tenants report that they actively programme their controls (i.e. change settings to suite their requirements) they will be recorded as 'frequently' engaging in this behaviour. If they have had the facility pre-programmed (as outlined above), but have not adjusted settings, this will not be recorded as a behaviour that they 'never/very rarely' engage in, even though the controls are essentially programmed. Tenants who only use the timer in the winter are still considered to be 'frequently' practicing that activity, as this is the time when heating use is relevant.

Table 14: Behaviour Change Related to Programmable Heating Controls

Do you programme your central heating controls to come on at different times?						
	Before Technical Intervention and Informational Intervention 2			After Technical Intervention and Informational Intervention 2		
Sample Group	Frequent	Occasional	Never / Very Rarely	Frequent	Occasional	Never / Very Rarely
Exposed to Informational Intervention 2	1 (8%)	0	12 (92%)	4 (31%)	0	9 (69%)
Not exposed to Informational Intervention 2	2 (15%)	0	11 (85%)	6 (46%)	0	7 (54 %)
Total	3 (12 %)	0	23 (88 %)	10 (38 %)	0	16 (62 %)

Description

There was a significant change in behaviour with regard to programmable heating controls. Before the interventions a majority of tenants, 23 (88%) across both groups did not programme their central heating to automatically switch on at chosen times of the day. After the interventions the behaviour of programming central heating controls changed with 7 (27%) tenants in total changing behaviours from 'never/ very rarely' to 'frequent' programming of central heating controls, and the remaining 16 (62%) of the total, continued the behaviour of not programming controls. The total number tenants with programmed central heating controls (but passively used) is likely to be much higher, due to the controls being pre-programmed by Gentoo Group and tenants not actively using the programme controls. The sample group

exposed to Informational Intervention 2 had 3 (23%) tenants changing to a 'frequent' behaviour of programming central heating controls, and the sample group that was not exposed to Informational Intervention 2 had 4 (31%) tenants changing to a 'frequent' behaviour to programme central heating controls.

There is no significant difference in behaviour change between the group that was exposed to Informational Intervention 2, and the group that was not exposed to this intervention.

Discussion

The most likely reason for this change in behaviour is that the facility to programme central heating was introduced and this allowed tenants to use it where they previously were unable to, because the facility was not previously fitted, did not work or tenants did not know how to operate the facility. Also tenants may not have programmed their central heating because they rarely used the central heating prior to the retrofit, and thus had less need to programme it.

The change in behaviour was relatively limited considering the introduction of new technology to all homes, with 16 (62%) tenants maintaining the behaviour of not actively programming their central heating controls. Two potential reasons have been identified for the limited change of behaviour to programme central heating controls: it may be due to tenants' limited understanding of how to use the heating controls to programme central heating times, and/or a preference for switching the boiler on and off manually due to perceptions of energy (and thus money) being wasted when central heating is programmed.

Tenant understanding of heating controls

Tenants' limited understanding of how to use the central heating controls may be attributed to insufficient training on how to use the new technology for a number of reasons as outlined below.

During the hours when retrofit works were underway (approximately 9.00 am to 5.00 pm), a number of tenants were not available at the property to receive guidance on how to use the heating controls. Tenants were either living in a different location for the duration of the retrofit works, out at work, or not in the property for other reasons.

Tenants stated that the guidance was provided by members of the Gentoo Group installation team. However, it is not clear if the Gentoo Group installation team had energy advice training, and there was no evidence that tenants were informed of the importance of heating controls in managing energy use and thus costs. The quality of communication and its relevance to tenant's needs may have impacted on tenants' engagement and understanding of the technology.

Tenants were provided with a brief verbal description and demonstration of the heating controls and no reference material was provided other than the manufacturer's manual, which some tenants described as being complicated and having small script:

> *"...well we don't understand the little book we got, it's tiny writing and you're like, and you think, oh it goes on and on, so we just put it on when we want" (306FSL)*

This type of communication may not have been sufficient for tenants to learn how to use the controls effectively, or to provide a suitable reference should they forget what they were taught by the installer. However, some tenants who took up the behaviour of programming did so by learning from the installer guidance and tenants also learned how to use the heating controls, without guidance, by reading the manufacturers manual (with some difficulty) and/or trial and error:

> *"...they left me a guide book which was quite complicated...with tiny little script. Basically it took me about 20 minutes to actually find the section I was supposed to find, but I figured it out myself" (101FRF)*

It is possible that because, Gentoo Group, installed and pre-programmed the equipment, tenants felt that the technology was already set up by Gentoo Group and that they did not (or should not) use it as a tool to manage their energy use:

> *"I don't know how to use it [the central heating control]...I haven't got a clue what it's there for, all that I know is, it comes on every 2 hours so I was petrified me bills were gonna be huge so I've had to turn it off by the mains and I just use it when I, cos if you put that on now it'll not come on till like 3 o'clock to 5 and it heats your house up to a certain level, but I was thinking I would never, ever leave me heating on for 8 hours a day, never ever, so I switched it off by the mains out there...god knows what it's there...it's set by government rules or whatever, I cannot change that, no matter for all the love in the world I cannot change the buttons, it's set automatically" (326SLF)*

Pre-programming included four heating intervals through the day, and a number of tenants stated that they did not wish for heating to come on at these intervals, but did not know how to re-programme the controls. Tenants may not have fully taken

'ownership' of the facility, thinking it was automatic or not to be tampered with, and thus, without learning by using the technology, understanding was not developed.

A number of tenants reported that they had relied on Gentoo Group to change the programme settings as they did not understand how to use the facility. This links to the wider issue of institutional and individual responsibility and the perceptions by many tenants that their social housing provider is responsible for meeting their needs regarding technology which is not considered their own (e.g. fabric of the house, central heating system and controls). Here responsibilities of the tenant to learn how to use controls are somewhat deferred to the institution. This is less of a problem in the privately owned housing sector as it clear that the homeowner is responsible for the maintenance and use of technology in order to meet their needs, and there is no immediate institution to provide a 'safety net' if the individual does not understand the technology.

The communication programme to train tenants on heating controls failed to ensure engagement with each household; provision of strong and diverse communication techniques: and did not emphasise the relevance of the training and potential empowerment of the facility to assist tenants' needs in order to encourage 'ownership' of the facility.

Manual heating control due to perceptions of wasted energy

Tenants who do not actively programme central heating controls have a preference for turning the boiler off (pilot light only) and on (either hot water on standby, or both hot water and heating on standby) manually at the main boiler controls. A number of these tenants stated that they did this because they perceive it to save more energy than programming heating controls:

> *"We just find it easier to just control it ourselves rather than timing and things...if I wanted to I could look in the book and work it out [how to programme central heating] if I really wanted to but it'll be a waste [of energy], I'd rather just put it on and off as I need it now"* (306SLF)

Hence some tenants will also want to override the pre-programming that they do not know how to control and do this by manual switch off. As one tenant noted:

> *"So they installed the central heating and they must've put it onto timed...for about four times a day, well it was the summer and I didn't want it on timed, plus I didn't know what time it was gonna come on or go off and sometimes it was on and I didn't want it on, so I started where I was switching the boiler off altogether"* (352SLF)

Some tenants also stated that they did not want the heating to come on while they were in bed because they perceived it as a waste of energy or because it may disturb sleep of household members through heat or noise. It is not clear which behaviour saves the most energy–switching on and off their heating manually or keeping it on standby and programming it at timed intervals. Nevertheless, this common behaviour demonstrates that many tenants have an active approach towards energy conservation, even if they are not fully informed on the techniques to achieve the best results.

The behaviour of switching the boiler off manually may be a habit which is continued in relation to the previous heating technology of back-boiler, prior to retrofit, where the water heating or central heating was mainly used by manual switching.

Programming the central heating controls is considered an energy saving behaviour for the purpose of this research. However it should be noted that tenants who 'never/very rarely' programme their heating, may sometimes be even more strict energy savers than tenants who programme the heating. Tenants who do not programme, only ever switch on the boiler when needed (e.g. for washing dishes or for a bath) otherwise it is completely switched off. Tenants who programme will have the boiler on hot water until the time at which the heating automatically switches on.

Patterns of Behaviour Related to Energy Use

- The introduction of the heating controls technology from the Technical Intervention created a significant change in the behaviour of tenants to actively programme their central heating controls.

- A significant number of tenants did not change behaviours to actively programme their central heating controls, due to the following reasons:
  - Tenants did not change behaviours because they did not understand how to programme the central heating controls.
  - Tenants manually switched the hot water and/or central heating on or off at the combi-boiler controls, because they wanted control of energy use for hot water and/or central heating, to avoid energy use at timed intervals when they did not wish to use it, or when it was not required.
  - Tenants manually switched (as above), due to a habit formed through previous use of a back boiler.

▪ In the context of social housing it is unclear if the behaviour of manual switching conserves more energy, than the behaviour of programming central heating controls.

5.2.2.2 Use of thermostatic control

Context

Before the technical intervention, tenants did not have access to the facility of a thermostatic control (built into the central heating controls). Therefore all tenants could not change settings on the thermostat and adjust temperatures, thus were recorded as 'never/very rarely' conducting this behaviour. After the Technical Intervention, tenants who reported that they used the thermostat setting of 20˚C or below frequently were recorded as 'frequent'.

Some tenants would set the thermostat setting higher than 20˚C temporarily, to heat the house up more quickly, then would reduce the thermostat setting to 20˚C or below for the duration of heating use. Tenants also reported that they use thermostat settings higher than 20˚C, depending on the existing weather conditions. Tenants with the latter two behaviours are recorded as 'occasional'. Tenants who reported that they tended to have the thermostat settings above20˚C were recorded as 'never/very rarely'. Tenants who did not know what thermostat setting they used and therefore were recorded under the category 'Don't know'.

Table 15: Thermostat use Behaviour Change

Do you keep your thermostat temperature at no more than 20˚C?							
	Before Technical Intervention and Informational Intervention 2			After Technical Intervention and Informational Intervention 2			
Sample Group	Frequent	Occasio-nal	Never / Very Rarely	Frequent	Occasio nal	Never / Very Rarely	Don't know
Exposed to Informational Intervention 2	0	0	13 (100%)	9 (69%)	2 (15%)	2 (15%)	0
Not exposed to Informational Intervention 2	0	0	13 (100%)	9 (69%)	1 (8%)	1 (8%)	2 (15%)
Total	0	0	26 (100%)	18 (69%)	3 (12%)	3 (12%)	2 (8%)

Description

There was a significant change in tenant behaviour with regard to thermostat use. Before the interventions all 26 tenants did not keep thermostat temperatures below 20˚C. After the interventions this behaviour changed with 18 (69%) tenants frequently keeping thermostat settings below 20˚C and 3 tenants occasionally keeping thermostat settings below 20˚C. Three tenants used thermostat settings slightly higher than 20˚C and one tenant did not know what setting they used on the thermostat, when using the central heating. Nearly all tenants reported that they were using the thermostatic controls and demonstrated that they understood how to use them.

There is no significant difference in behaviour change between the group that received written and verbal energy information, and the group that did not receive this information. However, the two tenants that did not know what thermostat settings they used were in the group receiving no written and verbal energy information.

Discussion

The most likely reason for the significant change in behaviour is that the facility of the thermostat (built into the heating controls) was introduced, allowing tenants to take up the behaviour of using thermostat control settings. Prior to the Technical Intervention they were unable to engage in this behaviour.

It is not clear why a majority of tenants choose to maintain thermostat settings at 20˚C or below. Tenants may be aware that lower temperatures use less energy as they could have been informed by the installer(s) or from another source (such as the media or energy supplier), or may already be aware of this. Tenants may also have a preference for temperatures in this range as houses were reported to be much cooler before the retrofit. Tenants may have adjusted to these cooler temperatures, and thus find cooler temperatures more comfortable than temperatures arising from higher thermostat settings.

The heating controls allowed tenants to increase the thermostat temperature setting in 0.5˚C increments by each push of the relevant button tenants may have raised the thermostat temperature setting slightly so that the heating engages, but controls still indicate 20˚C or below:

> *"It's on fifteen now but it doesn't work until you put it a little bit higher when the little flame comes up [indicator that heating is on]...so I put, if I put it on about seventeen it's, it'll stop there" (312SLF)*

Another possibility is that the factory or pre-programmed setting as installed by Gentoo Group is set to 20˚C or below, when the heating switches on at its timed interval and this is the temperature indicated and thus the temperature which tenants are reporting:

> *"At the minute it is coming on at 19[˚C]...it's automatic, it just automatically comes one and then I turn it off" (21FRF)*

The three tenants who kept temperatures higher than 20˚C, had set the thermostat slightly higher to 21-22˚C, and this may do with personal preference or possibly because of the way the thermostat detects temperatures in different households. Two tenants had raised issues with the location of the heating controls which contain the thermostat. They are usually located in the hallway of the house, typically the coldest part of the house and this is a problem because the current temperature it is reporting (and target heating temperature) only relates to this part of the house:

> *"It's not the best place to put it 'cos it's right in direct sunlight in the passage so you get, it can be a freezing, freezing cold day and you get the sun beating in that bit window and it says it's 22 degrees or something and you're sitting here [in the living room] dithering [feeling very cold] so it turns itself off all the time...it is other times, when the sun's moved away from there it's absolutely freezing out in the hallway and you can be sitting in here and you can be absolutely red hot, but out there it'll say it's like 11 so to me it's in a silly place...and you're constantly turning it up and down, up and down all the time" (322SLF)*

If a tenant sets the target temperature setting for the house, for example 19°C, the heating will actually heat the rest of the house to a higher temperature because the thermostat will take longer to reach its target temperature. More gas will be used, because the other rooms in the house would normally reach target temperature sooner and then the heating would only use small amounts of gas to maintain that temperature. Also conversely if temperatures were sometimes higher in the hallway due to sunlight on the controls, higher temperature settings would have to be entered into the thermostat to heat the house as the thermostat would switch off the heating before the remainder of the house reaches target temperature. The location of the thermostat in a cooler part of the house may potentially have accounted for the lower temperature settings reported by tenants. This is because tenants would tend to raise the temperature setting by 0.5°C or 1°C to activate the central heating,

and the lower temperature thermostat reading would be the start point. So if hallway temperatures were 17°C tenants would report that the temperatures settings they used were 17.5°C or 18°C and well below the 20°C threshold associated with the question asked of the tenant.

The tenants who did not know their thermostat temperatures settings are likely to be unaware of how to use the technology, or may pay limited attention to the heating control readings.

Patterns of Behaviour Related to Energy Use

- The introduction of the heating controls technology from the Technical Intervention created a significant change in behaviour in a majority of tenants. Tenants used the thermostatic controls to change temperatures to suit their needs.

- A majority of tenants kept thermostat settings at 20˚C or below.

- Tenants who used thermostat settings above 20˚C, used thermostat settings at the slightly higher settings of 21-22˚C.

- Tenants changed behaviours to use technology and conduct energy saving behaviour, because they were motivated to save energy and had knowledge and skill of how to do this.

- Thermostatic controls were simpler to use in comparison with the controls to programme central heating to come on at timed intervals and this may be a reason why tenants changed behaviours to effectively use this facility.

- Two tenants from the group not exposed to Informational Intervention 2 were unaware of the thermostatic settings that they use and these cases may indicate the importance of training or guidance on thermostat controls.

- There is a potential issue with the location of the central heating controls, in which the thermostat is contained due to the fluctuation of temperature of its location, and not always reflecting the remaining rooms of homes.

5.2.2.3   Use radiator controls to provide heat as and when required

Context

Before the retrofit installation tenants did not have access to the facility of thermostatic radiator controls, therefore all tenants could not manage temperatures and were recorded as 'never/very rarely' conducting this behaviour. It was not always clear from the interviews, if the tenants used the controls occasionally or frequently, therefore tenants who reported that they used the radiator controls were recorded as 'Frequently or Occasionally' conducting this behaviour.

Table 16: Behaviour Change in the use of Radiator Controls

Do you use the radiator controls to provide heat as and when required?					
	Before Technical Intervention and Informational Intervention 2			After Technical Intervention and Informational Intervention 2	
Sample Group	Frequent	Occasional	Never / Very Rarely	Frequently or Occasionally	Never / Very Rarely
Exposed to Informational Intervention 2	0	0	13 (100%)	10 (77%)	3 (23%)
Not exposed to Informational Intervention 2	0	0	13 (100%)	11 (85%)	2 (15%)
Total	0	0	26 (100%)	21 (81%)	5 (19%)

Description

There was a significant change in tenant behaviour with regard to the use of radiator controls. Before the interventions all 26 tenants did not use the radiator controls to provide heat as and when required. After the interventions this behaviour changed with 21 tenants taking up the behaviour either frequently or occasionally. Five tenants did not take up the behaviour of using the radiator controls to provide heat as and when required.

There is no significant difference between the group that received Informational Intervention 2 and the group that did not receive the informational intervention.

Discussion

The most likely reason for this change in behaviour is that the facility of the thermostatic radiator controls was introduced and this allowed tenants to use radiator controls to provide different amounts of heat as and when required, where previously they were unable to conduct this behaviour. Tenants who did not take up

the behaviour of using radiator controls did not do so because they were unaware of them, did not know how to use them and/or left them on installation settings:

> *Oh I didn't know, oh I wasn't aware of that [facility of radiator controls]" (83FRF)*

> *I don't know how they [radiator controls] work either (326SLF)*

Radiator controls are relatively simple to use and tenants may have become aware of their use through installer communication or Gentoo Group members of staff. Tenants may also have become aware of them from friends or family who have them installed in their homes.

However, it is clear that for a nearly one fifth (19%) of tenants, radiator controls represent an unfamiliar facility, which they are not aware of or do not understand how to use them in allowing them to manage heating and energy. This may indicate that the communication programme did not access all tenants and provide sufficient understanding of radiator controls and their role in managing tenants heating and energy use.

Patterns of Behaviour Related to Energy Use

- The introduction of the radiator control technology from the Technical Intervention created a significant change in behaviour in a majority of tenants.

- Radiator controls were simpler to use in comparison with the controls to programme central heating to come on at timed intervals and this may be a reason why tenants changed behaviours to effectively use this facility.

- Tenants who did not change behaviour reported this was because of being unaware of them, not understanding how to use them and/or leaving them on installation settings.

5.2.2.4   Fire use for space heating

Context

Tenants were not asked specific questions regarding use of the fire for space heating, therefore the following description and discussion are based on other information gathered from the interviews.

Before the Technical Intervention all tenants had a gas fire which 25 (96%) of all used regularly for space heating. The electric fire was installed with the intention that tenants would not use it as a source of heat and that tenants would only use the electric fire for aesthetic purposes from that point onwards. It was Gentoo Group's aim to communicate to tenants that the central heating is more efficient than the electric fire for space heating and this would then result in tenants changing behaviours to constantly use only the central heating system for space heating.

Description

There was a significant change in tenant behaviour with regard to using the gas/electric fire for space heating. Before the Technical Intervention, 24 (92%) tenants used the gas fire to provide heat with a majority of tenants using the fire frequently in preference of central heating when heat was required. After the interventions 10 (38%) tenants did not change behaviours as Gentoo Group intended and continued to use the electric fire frequently for space heating. These tenants may also use their central heating at other times however, when tenants require short-term heating and/or are spending periods of time in the living room they will use the electric fire instead of the central heating.

Discussion

Prior to the interventions all tenants regularly used the gas fire as a source of heat. Tenants said this was due to the ineffective heating system, the house suffering drafts and not retaining heat and the house taking a long time to heat. Thus tenants perceived that it would be costly and a waste of money to put the central heating on. Tenants therefore used the gas fire and tended to spend more time in the living room. Some tenants used electric heaters for other rooms, or sometimes instead of the gas fire, as they perceive the electricity to be cheaper than gas if used in this context and way:

> *"...except for my fire at the minute...keep it off all day and I try to put it on a couple of hours on a night and I've got my [electric] heater for when I get up in the morning for the bairn [child]. By the time you heat the whole house through [with central heating] the gas bill will be ridiculous" (326SLB)*

Tenants occasionally used the central heating when it was very cold and/or other parts of the house required heat. Tenants perceived that heating only the living room with intermittent use of the gas fire (and for some tenants, electric heaters), saved more money rather than heating the whole house over a longer period.

After the technical intervention,10 tenants continued to use the electric fire (which replaced the gas fire) as a source of heat. This may be due to a continuation of perceptions that tenants had prior to the interventions and thus a continuation of the same behaviour. This perception may have been accurate before the modernisation. However due to the Technical Intervention the central heating and insulation fabric is more effective, and this perception may no longer be relevant. This is an example where previous behaviours or perceptions have continued after the modernisations, even though this behaviour may be no longer applicable for saving energy due to a change in technology.

Half of the tenants who continued to use the electric commented that it was inadequate compared to the gas fire and four tenants said that costs to run the electric fire were higher than the gas fire. Two tenants were unsatisfied with the electric fire, regretted its installation and wanted to have their gas fires returned.

However in general tenants did perceive an advantage in the electric fire as there is no need for the ventilation brick for the gas fire health and safety reasons, which was reported to be very drafty, and therefore affected comfort. Some tenants stated that they have always liked using a warm fire in the front room and would not like their living room not to have a fire. Even though tenants perceive that the gas fire uses more energy than the electric fire they want to have their gas fire back, the need for immediate comfort overrides the extra cost or environmental concerns:

> *"I'd have me gas fire back...It's rubbish that [electric] one...even with the pipes [central heating] on in the morning the room's still a bit cold and I put that on and it takes ages to warm it up...I mean I know it's more energy like but I miss me gas fire" (17FRF)*

The tenants who use the electric fire may also use the central heating as a source of heat. Electric fire usage is usually in-between periods of central heating use, but sometimes briefly at the same time while central heating begins to warm the house. This delayed access to warmth may be linked to some of the tenants' preference for manual control over the heating rather than programming heating controls (see 5.2.2.1), however tenants may need to access warmth at a time they cannot plan for and may still require quick access to heat.

Tenants often perceive that it costs more to put the central heating on timed intervals for it to be warm when they get up, rather than using the fire for a short time. Tenants tend to use the electric fire for shorter periods, to rapidly provide

warmth and/or when they are only occupying the living area. Tenants sometimes felt it was necessary to use the fire for short heating periods for comfort and for more vulnerable occupiers such as children or the elderly.

In some cases it may be suitable and less costly for some people to use the electric fire for their heating needs, for example: only one person may require heat in only the living room for a short time before they go to work, or if occupiers are only in the house for intermittent short periods.

Four tenants who did not use the electric fire as a source of heat, commented that they only used the light on the fire, but not the heat element. This was said to be for decorative purposes and tenants stated that it gave the perception that the fire was on and psychologically gave them the feeling that the room was warmer because of the colours and glow:

> *"I put the light on just to give the illusion that the, because if I see a light then I feel warm anyway. I know it sounds stupid but I'm one of these people if I look and there's a light on the fire then I feel warm even if the fire's not lit" (99FRF)*

Gentoo Group's intention was that upon the provision of advice, tenants would not use the electric fire and instead would use the central heating and radiator controls to provide heat where required. However, some tenants stated that they did not receive advice from Gentoo Group on fire use. Where advice was provided (to use central heating instead of the electric fire) the alternative options (such as using radiators to isolate central heating energy to one room to save gas) were not made clear. In some cases the tenants may not have received, read or taken in any information on heating methods where it had been delivered, due to absence from the property or other reasons. Tenants were only advised that using the central heating was more efficient and cheaper than using the electric fire and they should avoid using the electric fire as a source of heat. Nevertheless, it is likely that tenants would not necessarily change behaviour based on targeted advice and training, due to some of the overriding causalities outlined earlier.

In a number of cases tenants express a weak understanding of what method is most cost effective to provide warmth in their homes. For example: after the modernisations were installed, some tenants (particularly those on pre-payment or budget schemes) were aware that their electricity bill had significantly risen in cost, but were continuing to use the electric fire as regularly as they used their gas fire. It

is possible that rising costs could have been due to rising utility costs from suppliers, however, the same tenants reported that they were using more electricity and less gas than they did before the Technical Intervention. Therefore it is more likely that rising costs were due to the continued behaviour of using a fire for space heating along with the change in fire technology and fuel switching from gas to electricity.

Education in the area of cost effective heating methods would help to improve understanding, however this must take into account the different circumstances occurring in different types of household. For example, for a single person who works double shifts and goes to bed early, it may actually be a negligible saving by using central heating rather than the electric fire intermittently (and if using central heating for longer periods, education on thermostatic radiator controls may be of more importance). Alternatively, a five person family who spent longer periods of time in the house is likely to benefit from using central heating rather than the electric fire (and education on heating controls may be of more importance). This indicates that any social learning mechanism to improve tenant understanding and ownership of energy management needs be formed from a tailored approach, based on the individual narratives and circumstances in each household.

Patterns of Behaviour Related to Energy Use

- The replacement of the gas fire with an electric fire (in conjunction with central heating) technology from the Technical Intervention created a significant change in behaviour in more than half of tenants.

- The communication of information was a factor which encouraged the change in behaviour in addition to the introduced central heating as an alternative means of space heating.

- Tenants did not change behaviours due to being unaware or unclear on the most efficient way to use space heating.

- A number of tenants stated a preference for using a fire for space heating instead of the central heating and nearly half of the tenants did not change behaviours and continued to use the electric fire.

- Some tenants regretted having the electric fire installed and would like to have their gas fire back.

- Tenants did not change behaviours because of perceptions and routines developed prior to the interventions which were continued afterwards.

- Some tenants initially used the electric fire but then stopped using it because it was ineffective and costly compared to the gas fire.

5.2.2.5   Hot water use (bathing)

Context

Before the retrofit installation tenants did not have access to the facility of a mains fed shower with temperature control. However, some tenants had invested in their own shower facilities, such as electric showers or, in a few cases, shower adapters which fit to conventional bath taps. All tenants (except one), received a mains fed shower in replacement of their own shower equipment and their existing bath was replaced with a new bath which the mains fed shower was attached to. One tenant did not have a bath and only had a shower before the modernisations, they were issued with both a bath and a mains fed shower as part of the Technical Intervention. Tenants may state that they mainly have showers, have both baths and showers (at different times or days) or mainly have baths. The responses reflect the choices of each tenant being interviewed, however other household members may have completely different bathing behaviours.

Table 17: Behaviour Change related to bathing

Do you tend to have showers instead of baths?						
	Before Technical Intervention and Informational Intervention 2			After Technical Intervention and Informational Intervention 2		
Sample Group	Mainly Showers	Baths or Showers	Mainly Baths	Mainly Showers	Baths or Showers	Mainly Baths
Exposed to Informational Intervention 2	2 (15%)	1 (8%)	10 (77%)	10 (77%)	2 (15%)	1 (8%)
Not exposed to Informational Intervention 2	4 (31%)	2 (15%)	7 (54%)	6 (46%)	3 (23%)	4 (31%)
Total	6 (23%)	3 (12%)	17 (65%)	16 (62%)	5 (19%)	5 (19%)

Description

Before the modernisations 17 tenants 'mainly' had baths, 3 had baths or showers and 6 'mainly' had showers. After the interventions 5 'mainly' had baths, 5 had baths and showers and 16 'mainly' had showers, in total 21 tenants use the shower to some degree after the intervention. This indicates that there was a significant shift towards shower use after the retrofit, however a proportion of tenants continued to mainly use baths and did not change behaviours to use the introduced technology of

the shower. Overall 10 tenants still used the bath to bathe alongside showers or mainly used baths.

There is a slight difference between the group that received the written and verbal energy information and the group that did not receive written and verbal energy advice. The tenants in the former group reported changes in bathing behaviour, from 'frequently' bathing by using baths to 'frequently' bathing by showers.

Discussion

The most likely cause for the tenants, change in behaviour to use showers more is that the facility was introduced by the Technical Intervention and therefore tenants had the opportunity to use the technology. Many tenants stated that they understood that having a shower uses less water than having a bath, and they may have been motivated to use the shower instead of the bath because they perceived it would save money. Tenants also expressed that it was very convenient to use the shower and less time consuming compared to the bath especially when using the back-boiler prior to retrofit, so this could also be a strong driver for a change in this behaviour. However, caution must be taken when evaluating actual energy, carbon and cost savings from the installation of mains fed showers as part of the Technical Intervention. In terms of hot water use for bathing, actual savings may be in doubt due to the increased frequency of bathing that tenants reported.

Before the interventions a majority of tenants were restricted to baths, with a long period of water heating (1-3 hours) from the inefficient back boiler, before they could use hot water. These inconvenient circumstances encouraged tenants to conserve hot water by having less frequent baths in the household (2-4 times per week) and sometimes sharing bath water with other household members. It is also possible that awareness of inefficiencies and energy costs may also have encouraged hot water saving behaviour.

After the interventions, tenants reported that they welcomed the convenience of instant hot water and this is accompanied by more frequent bathing. Tenants state that they bathe more frequently since the interventions, some said they now shower daily and that some household members may have two showers (or in some cases three) a day. Tenants find showers to be quicker and easier to bathe rather than using the bath.

"They're quicker...because the old system when you put it on you had to wait an hour for the water heat up whereas this you just flick it on and it takes not even a minute for it to come through to heat up.

Right yeah yeah, so it's instant shower whenever you need...and the bairns love it so they're in the shower all the time. But with the bath like the old one you used to wait forever like say five o'clock you used to put it on, wait till six o'clock so you could get them in the bath..." (15FRF)

Based on these and other statements it is estimated that the frequency of showers is 4-14 per week for each household member mainly using showers. Previous sharing of bath water was less likely, since showers are designed for one person at a time and hot water is immediately expelled. Those tenants who use baths and showers to bathe throughout the week may have increased their use of hot water. There is also a potential increase in the frequency of baths for those tenants that prefer baths due to this increased convenience of instantaneous hot water.

Some tenants said that their energy bills had increased since the Technical Intervention and this pattern of hot water use may be linked. Energy use may have increased as an impact of increased convenience provided by technology, however the benefits this may provide household members in terms of quality of life may justify the cost for the individual. As this was not a longitudinal study it was not possible to follow up on behaviours after the initial retrofit period. This may have indicated if these hot water consumption behaviours continue, as it may be possible that they are temporary due to the novelty of the technology and impact on lives. Tenants may also modify behaviours to bathe less frequently again after fully becoming aware of the increased costs if this indeed is evident.

Some of the tenants who had showers before the retrofit continued the behaviour of using the shower after the retrofit, similar to those tenants who had baths and continued this method of bathing after the retrofit despite the more convenient and efficient shower. Those tenants who have a preference for a bath will occasionally use the shower if they have time restrictions. Tenants did not mention any problems with understanding and using the newly fitted showers and found the thermostatic control to be very useful at regulating heat, to conserve energy, for comfort reasons or for safety when bathing young children. One tenant indicated a problem with the installation position of the shower, with it being too low for practical use and thus uses the shower less than preferred and has more baths. One tenant did not receive

a shower as part of the modernisations and therefore could only take baths, it is not clear why this was the case.

When asked if they take baths or showers some tenants immediately express that they like having baths:

> *"Oh I'm a bath person to be honest, but still have showers occasionally" (99FR)*

> *"I love my baths, but in between its a shower" (107FR).*

Tenants who state that they are conservative in their energy use, have still expressed a preference for baths and it may be possible that this preference overrides the motivation to save energy. Tenants who take baths as well as showers or mainly take baths expressed a number of reasons for this which stem from the theme of comfort. Some found it too cold in the shower and liked the warmth and relaxation of a bath and for some it aided medical problems. Tenants also reported on a number of occasions that baths are used for younger children in the household. Before the interventions the house was cold in general and bathrooms were still reported to be cool even post intervention due to drafts or installed draft excluders. When hot water is added to baths they heat up the general air temperature better than a shower and provide a warmer room and warmer bathing experience, so it is likely that tenants have continued a previous behaviour linked to comfort in previous (or present) cooler rooms and have continued this. Linking to the theme of cooler ambient temperatures, tenants expressed a preference for baths in the winter time and showers for the summer time.

> *"In the summer I generally have a shower but I like a nice warm bath in the winter" (17FRF)*

Patterns of Behaviour Related to Energy Use

- The installation of the mains fed shower technology as part of the Technical Intervention created a significant change in behaviour in almost half of the tenants.

- Some tenants perceived the shower to save more energy than having a bath and thus changed behaviour due to motivations to saving energy.

- Tenants used hot water more frequently, increasing the number of showers and in some cases baths after the Technical Intervention due to the convenience of the combi-boiler rather than the back boiler.

- Some tenants took showers instead of baths because of the increased convenience and time saving compared to using the bath.

- Some tenants were unclear on which type of bathing consumed the most energy.

- Some tenants take baths as this provides a warmer more comfortable experience than showers and are willing to use more energy for this experience.

- Some tenants continued the behaviour of having baths because they preferred having baths.

- Continued behaviours of using the bath instead of the shower may be linked to behaviours when the house was cold before the Technical Intervention, however some tenants did say bathrooms were still cold.

5.2.3 Controlling Drafts and Maintaining Thermal Comfort

These energy use behaviours relate to controlling drafts and maintaining thermal comfort and also have indirect relationships with the technology installed as part of the Technical Intervention. Tenants do not interact directly with the technology, however the technology may affect the household environment, which may in turn lead to behaviour change.

5.2.3.1   Control drafts to maintain thermal comfort

Context

It was not clear how frequently tenants controlled drafts in their home, therefore tenants who stated that they controlled drafts to any degree were recorded as 'frequent' and tenants who stated that they did not control drafts were recorded as 'never/very rarely'. No tenants were recorded as 'occasional'.

Table 18: Behaviour Change related to controlling drafts

Do you try to control drafts in your home to stop heat escaping?						
	Before Technical Intervention and Informational Intervention 2			After Technical Intervention and Informational Intervention 2		
Sample Group	Frequent	Occasional	Never / Very Rarely	Frequent	Occasional	Never / Very Rarely
Exposed to Informational Intervention 2	9 (69%)	0	4 (31%)	3 (23%)	0	10 (77%)
Not exposed to Informational Intervention 2	10 (77%)	0	3 (23%)	6 (46%)	0	7 (54%)
Total	19 (73%)	0	7 (27%)	9 (35%)	0	17 (65%)

Description

Before the interventions 19 tenants attempted to control drafts in the home to prevent heat escaping and to maintain comfort with 7 tenants stating that they did not attempt to control drafts. After the interventions, 10 tenants ceased to conduct the draft controlling behaviour and 9 tenants continued the behaviour of controlling drafts.

There is a significant difference between the group that received informational intervention and the group that did not receive the informational intervention. In the group that received the informational intervention 67% of tenants ceased to conduct the behaviour of controlling drafts, but in the group without written and verbal advice 40% ceased to conduct draft controlling behaviour.

Discussion

Before the interventions tenants reported that the house was very drafty and cold as a result. Thus thermal comfort in some cases influenced tenants' behaviour to control drafts. Drafts came from window areas, under external and internal doors, the ventilation gap for the gas fire (situated on high on the windowed external wall), flooring and various other areas. As a result most of the tenants attempted to control drafts in various ways, such as; fitting curtains to external doors; for internal doors, keeping doors closed, installing draft excluders, laying down 'snake' draft blockers or towels; blocking the gas fire ventilation with newspaper or card. Those tenants who do not try to control drafts feel that they cannot control them, feel overwhelmed, that there are too many drafts to prevent and it would be too time consuming, or do not want use draft controlling methods because they want their house to look tidy.

> *"You can't control them anyway" (326SLB)*

> *"I'd be here all day if I was trying to control drafts. I would honest to God. So no" (1FRB)*

After the interventions the tenants who 'Frequently' controlled drafts said that drafts had been reduced to a minimum and they no longer perceived it to be a problem that required draft controlling behaviour. This is likely to be due to improved levels of thermal comfort, as tenants reported that the house was warmer.

> *"Well it's all double glazing and that now and all the doors so you don't really need to" (15FRF)*

Some tenants who did not control drafts before or after the interventions, reported there were still draft problems relating to various parts of the house.

> *"Just under all me window sills, gaps by the workmen who've put them in probably... there's gaps and you can just feel it all coming through, the upstairs ones are the worst, terrible" (13FRF)*

The 9 tenants who continued the behaviour of controlling drafts reported that drafts still existed around the window areas, the front door, the stairway passage in the bathroom from a ventilator (installed as part of the retrofit) and various gaps which were created by retrofit works but not adequately insulated and sealed to prevent drafts. Some tenants had reported the issues related to the windows to Gentoo Group staff and after inspection, windows had not been installed to Gentoo Group's specification by the sub-contractors. Insulation foam had been removed from around the window area to retrofit the new windows and upon installation, insulation was not installed around the surrounding window cavity, nor were windows sealed from the outside. New windowsills were also installed directly on top of old windowsills rather than removing old materials and re-plastering for correct fitting of the new windows. Some tenants reported similar problems with the front door.

These issues lead to significant drafts emanating from the window areas around the house and front door in affected properties. It is not clear how many properties were affected by the inadequate installations but some tenants who were aware and proactive complained about the situation to Gentoo Group and sub-contractors re-installed windows correctly. Tenants who had the windows re-installed reported that window drafts were prevented and were satisfied with the improved comfort and warmth. However it is not clear if all properties were reviewed and had re-installation work or if re-installations were delivered to tenants who had inadequate windows, but did not complain. As the comfort situation for tenants had been improved by

draft reductions and effective central heating installation, some tenants may not have perceived a problem with the drafty windows and not complained as the situation was better in general.

Complaining about significant draft problems may be considered a form of draft controlling behaviour as tenants require Gentoo Group to complete works to rectify the situation. Tenants who continued to suffer drafts after the modernisations also conducted the following draft controlling behaviours: laying down draft blockers or installing draft excluders to internal doors to prevent the stairway passage and front door drafts coming into the living room, installing draft excluders to the internal doors and front door, packing gaps under windowsills with newspaper.

The significant difference in draft controlling behaviour between the two sample groups receiving or not receiving written and verbal guidance is due to tenants in one of the particular groups, still experiencing drafts and thus controlling them, rather than any informational impact. Also, Gentoo Group's sub-contractor was rectifying some of the installation issues and it is possible that some of those households in the group without written and verbal guidance may not had not yet received these improvements at the time of interview and thus not as many tenants had ceased draft controlling behaviour.

Patterns of Behaviour Related to Energy Use

- The installation of the external doors and double glazed windows technology as part of the Technical Intervention created a significant change in behaviour in almost half of the tenants.

- This particular change in behaviour may represent an example of the Technical Intervention influencing behaviour to be less conserving of energy than before Technical Intervention.

- The installation double glazed windows and doors led to the experience improved thermal comfort and some tenants no longer felt the need to control drafts.

- Just under half of tenants continued to experience drafts, which was likely to be due to inadequate attention to air tightness in the retrofit process and therefore continued to conduct behaviours to control drafts.

▪ The significant difference in draft controlling behaviour between the two sample groups exposed or not exposed to Informational Intervention 2 is due to tenants in one of the particular groups, still experiencing drafts and thus controlling them, rather than any informational impact.

5.2.3.2   Close curtains at night to keep the heat in

Context

If tenants reported that they only closed vertical blinds and not curtains they were recorded as 'occasional', though some tenants did not own curtains or did not have them currently fitted. The same vertical blinds were fitted to all homes, likely to have been issued by Gentoo Group at an earlier stage. Closing vertical blinds only was recorded as 'occasional' due to the lower impact of blinds because of their lower thermal insulating properties. If tenants reported that they closed curtains this behaviour was recorded as 'frequent'.

Table 19: Behaviour change related to closing curtains at night

Do you close curtains at night to keep the heat in?						
	Before Technical Intervention and Informational Intervention 2			After Technical Intervention and Informational Intervention 2		
Sample Group	Frequent	Occasional	Never / Very Rarely	Frequent	Occasional	Never / Very Rarely
Exposed to Informational Intervention 2	10 (77%)	3 (23%)	0	7 (54%)	6 (46%)	0
Not exposed to Informational Intervention 2	12 (92%)	1 (8%)	0	11 (85%)	2 (15%)	0
Total	22 (85%)	4 (15%)	0	18 (69%)	8 (31%)	0

Description

Before the interventions 22 tenants frequently closed the curtains and 4 tenants occasionally closed the curtains or closed the blinds. After the intervention 18 tenant frequently closed the curtains and 8 tenants occasionally closed the curtains or closed the blinds.

There was a marginal change in behaviour with 4 (15%) out of all tenants changing from closing curtains, to closing blinds only. There is a significant difference between the group that received Informational Intervention 2 and the group that did not receive the informational intervention. Within group that received the written and

verbal energy advice 30% of tenants stopped closing curtains and 8% of the group who did not receive written and verbal advice stopped closing curtains.

Discussion

There was a marginal impact on behaviour after the interventions, with only 4 tenants taking up the behaviour of closing curtains occasionally or closing blinds. Some tenants reported that they removed their curtains for the retrofit purpose, they then used the blinds afterwards and had either decided not to put them back again or had not yet put curtains up. This may be an explanation for the slight shift to blind use rather than curtain use. Some tenants were asked if the reasons for closing blinds and/or curtains, was this for privacy or for keeping heat in and they reported that it was for both reasons.

It is interesting that the patterns for the behaviour of closing curtains also, to a degree, reflects the patterns for controlling drafts in general. With more tenants in the group that received written and verbal advice still controlling drafts, this may indicate a relationship between the problems with the quality of the Technical Intervention still creating drafts, and the energy use behaviours of controlling drafts in general and closing curtains to keep heat in.

Patterns of Behaviour Related to Energy Use

- The installation of the external doors and double glazed windows technology as part of the Technical Intervention created a marginal change in behaviour.

- This particular change in behaviour may represent an example of the Technical Intervention influencing behaviour to be less conserving of energy than before Technical Intervention.

- The significant difference in draft controlling behaviour between the two sample groups exposed or not exposed to Informational Intervention 2 is due to tenants in one of the particular groups, still experiencing drafts and thus controlling them, rather than any informational impact.

- Changes in behaviour may also be linked to external circumstances, such as not having curtains up temporarily during and post retrofit.

5.2.3.3 Put on warm clothing rather than turn the heating up

Context

Tenants who stated that they would put clothing or use blankets or quilts, instead of putting the heating (or in some cases, fire) on or up, were recorded as 'frequent', tenants who said they would do this occasionally were recorded as 'occasional' so and tenants who stated that they would put the heating up rather than put on warm clothing were recorded as 'never/very rarely'.

Table 20: Behaviour Change regarding wearing on warmer clothing

Do you put on warm clothing rather than turning the heating up?						
	Before Technical Intervention and Informational Intervention 2			After Technical Intervention and Informational Intervention 2		
Sample Group	Frequent	Occasional	Never / Very Rarely	Frequent	Occasional	Never / Very Rarely
Exposed to Informational Intervention 2	10 (77%)	0	3 (23%)	7 (54%)	3 (23%)	3 (23%)
Not exposed to Informational Intervention 2	8 (62%)	2 (15%)	3 (23%)	5 (38%)	3 (23%)	5 (38%)
Total	18 (69%)	2 (8%)	6 (23%)	12 (46%)	6 (23%)	8 (31%)

Description

There was a significant change in behaviour regarding wearing warmer clothing instead of turning heating on or up. In total 6 (23%) tenants changed behaviour from frequently wearing warmer with 4 (15%) tenants changing to do this frequently and 2 (8%) tenants changing to never / very rarely conducting this behaviour.

There is no significant difference between the group that received informational intervention and the group that did not receive the informational intervention. All tenants follow a similar trend in behaviour.

Discussion

After the interventions there was a significant change in behaviour regarding wearing warmer clothing instead of turning heating on or up. There was a slight change in behaviour, with less tenants putting on warm clothing or using blankets and a slight shift towards occasionally conducting this behaviour and a minor number no longer conducting this behaviour. Some tenants said that they no longer felt the need to wear warmer clothing instead of putting the heating on, due to the improved warmth and comfort in the house.

This may indicate that some reasons for this behaviour may be based more on comfort levels improving rather than energy saving behaviour. It may be another example of energy efficiency improvements leading to behaviour that is not as conserving of energy than before the interventions. However another potential reason is the change in context of the families in the study, with new born babies, thus use of the heating for their benefit will reduce the amount of time tenants wear warmer clothing. Tenants who occasionally put on warm clothing, are those who would turn the heating on or up for children or visitors and would not use extra clothing in this instance, but would wear warmer clothing when there are no children or visitors in the house.

Patterns of Behaviour Related to Energy Use

- The Technical Intervention of external doors, double glazed windows technology and effective central heating created a significant change in behaviour with nearly quarter of all tenant wearing warmer clothing occasionally rather than frequently.

- This particular change in behaviour may represent example of the Technical Intervention influencing behaviour to be less conservative of energy than before Technical Intervention.

- The Technical Intervention of external doors, double glazed windows technology and effective central heating improved the level of thermal comfort for tenants. This is likely to have impacted on the behaviour to wear warmer clothing less frequently.

- Tenants with young children reported that they wear warmer clothing when children are not in the house and avoid using the heating. When children are in the house tenants use central heating and/or fires for their warmth and cease to use extra clothing for themselves.

5.2.4 Electrical Appliances and Lighting

These energy use behaviours relate to electrical appliance use and lighting use and have no direct relationship with the technologies installed as part of the Technical Intervention.

5.2.4.1   Use energy saving light bulbs

Context

Tenants who used any number of energy saving light bulbs around the house were recorded as 'frequent', and those tenants who did not use energy saving light bulbs were recorded as 'never/very rarely'. No tenants were recorded as 'occasional', as it was not possible to ascertain if tenants who energy saving light bulbs used them occasionally.

Table 21: Behaviour change related the use of energy saving light bulbs

Do you use energy saving light bulbs?						
	Before Technical Intervention and Informational Intervention 2			After Technical Intervention and Informational Intervention 2		
Sample Group	Frequent	Occasional	Never / Very Rarely	Frequent	Occasional	Never / Very Rarely
Exposed to Informational Intervention 2	9 (69%)	0	4 (31%)	11 (85%)	0	2 (15%)
Not exposed to Informational Intervention 2	11 (85%)	0	2 (15%)	12 (92%)	0	1 (8%)
Total	20 (77%)	0	6 (23%)	23 (88%)	0	3 (12%)

Description

Before the interventions, 20 tenants stated that they used energy saving bulbs and 6 stated that they did not. After the interventions, 23 tenants state that they used energy saving bulbs and 3 stated that they did not.

There is no significant difference between the group that received Informational Intervention 2 and the group that did not receive the informational intervention

Discussion

There was a minor change in the behaviour of using energy saving light bulbs with 3 tenants taking up this behaviour. During or after the Technical Intervention tenants

were redecorating and updating their homes and it is possible that some tenants installed energy saving light bulbs.

Tenants who don't use energy saving light bulbs and a number that do, dislike them because they find that they take too long to provide full light, are not bright enough, emit an unusual light or look unsightly.

Before the Technical Intervention some tenants could not install energy saving light bulbs because of the electrical system, i.e. they would flicker when installed or interfere with the television. Also some tenants noted that they were waiting for existing conventional bulbs to wear out before installing the energy saving bulbs. It is likely that tenants installed energy saving bulbs after the modernisations because the electrical installations were improved and conventional bulbs were replaced over time.

During the research period conventional bulbs were removed from the market in favour of energy saving bulbs, however a number of tenants already had supplies of bulbs provided free from energy companies or family or friends. Some tenants stated that they could not use them after the interventions, because of the type of light fittings they had. Tenants were generally unaware of newer bulb designs which looked more conventional, had multiple fittings and performed better and it is likely that opinions on energy saving bulbs were based on the older designs.

Patterns of Behaviour Related to Energy Use

- There was no significant impact on this behaviour due to the Technical Intervention or Informational Intervention 2.

- Changes in behaviour were linked to external circumstances.

- The majority of tenants who did not use energy saving light bulbs widely in their home due to:
  - Negative perceptions of the technology (e.g. preference for traditional design)
  - Knowledge and awareness of recent product designs which may meet tenant needs (e.g. range of fittings, speed of activation and light quality).

- Perceptions of the credibility of energy saving light bulb technologies can be impacted by tenants being introduced to the technology via low-cost or free early models of a technology.

5.2.4.2   Turn off all appliances completely when not in use

Context

Tenants who report that they turn off all appliances completely when not in use, including entertainment appliances are considered to be exhibiting this behaviour 'frequently'. Those tenants who generally switch off appliances, but may leave set top box or other appliances on stand-by when not in use, over-night, or say they sometimes forget are considered as 'occasional'. Tenants who state that they never switch off appliances fully are recorded as 'never/very rarely' engaging in the behaviour of switching off appliances completely when not in use.

Table 22: Behaviour Change related to switching off electrical appliances

Do you turn off all appliances completely when they are not in use?						
	Before Technical Intervention and Informational Intervention 2			After Technical Intervention and Informational Intervention 2		
Sample Group	Frequent	Occasional	Never / Very Rarely	Frequent	Occasional	Never / Very Rarely
Exposed to Informational Intervention 2	11 (85%)	1 (8%)	1 (8%)	11 (85%)	2 (15%)	0
Not exposed to Informational Intervention 2	8 (62%)	3 (23%)	2 (15%)	7 (54%)	5 (38%)	1 (8%)
Total	19 (73%)	4 (15%)	3 (12%)	18 (69%)	7 (27%)	1 (4%)

Description

Before the interventions, 19 tenants frequently switched off appliances completely when not in use, 4 did with some appliances or occasionally and 3 did not switch off appliances completely when not in use. After the interventions 18 tenants engaged in this behaviour frequently, 7 did with some appliances or occasionally and 1 did not switch off appliances.

There was a slight difference between the group that received Informational Intervention 2 and the group that did not. The former group predominantly conducted this behaviour frequently and one tenant started they engaged this behaviour with some appliances or occasionally. The latter group did not engage

this behaviour in as many numbers as the former group and after interventions, less tenants said they did this behaviour frequently and more tenants reported that they did this occasionally.

Discussion

There was no significant change after the interventions, although there was a minor trend in more tenants being recorded as 'occasional'. The difference between the group exposed to Informational Intervention 2 and the group not exposed to Informational Intervention 2 is minor and it is unlikely that changes can be due to the deployment of Informational Intervention 2 or non-deployment. It is likely that this behaviour has changed only slightly, because it is not linked to change in technology due to the Technical Intervention.

Those tenants, who stated that they frequently switched off all appliances completely when not in use, did so because they want to save money, but also due to concerns over safety risks from fire. Some tenants said that their parents had always practiced these behaviours for energy saving reasons or for fire safety and they had been taught to always do this and/or followed this behaviour themselves. Before the Technical Intervention, tenants reported that the electric system was out of date and that they sometimes had problems with shorts. Also, as long term residents in the area, tenants may have become aware of fires that local people have suffered in the past and fire prevention visits have been conducted in the area. These issues may have contributed to the behaviour of switching off appliances completely for safety reasons rather than to save energy, although the motivation to save energy also exists.

Tenants who were recorded as 'occasionally' engaging in this behaviour stated that they sometimes forgot to switch off appliances or it was inconvenient or difficult to switch off all appliances. Certain technologies were perceived to be inconvenient when switched off completely, for example television satellite boxes took time to boot and reconnect when switched off completely. Tenants did not want to wait for this process or because they did not understand the hardware, were concerned that it would stop working properly if switched off at the mains. However, some tenants did switch these off regularly and were not concerned about the delay or potential problems.

Some tenants also left on appliances such as modems, because they were concerned that it would cause technical problems if switched off or could not predict when internet was required by other householders. Particularly with entertainment appliances, some tenants did not switch off appliances because they perceived that it may damage the equipment from being switched on and off completely at regular intervals, rather than being left on standby. Some tenants did not switch off entertainment appliances because they shared multi sockets with other appliances that had to be left on (e.g. cordless phone, modem) and therefore left on the multi-socket and therefore entertainment appliances were left on standby. Difficulty accessing sockets or switches due to obstruction by furniture or appliances were also stated as reasons for not switching off appliances completely when not in use.

Patterns of Behaviour Related to Energy Use

▪ There was no significant impact on this behaviour due to the Technical Intervention.

▪ Barriers to switching off appliances completely when not in were due to:
- Convenience reasons (e.g. time taken to switch appliances on, access to sockets)
- Limited knowledge of this energy use behaviour in connection with certain appliances (e.g. concern of damage to appliances from switching on and off at the mains).

5.2.4.3   Boil only the amount of water you need when boiling the kettle

Context

Tenants who always tend to fill the kettle are marked as 'never/very rarely'. Tenants who occasionally boil more water than they need are recorded as 'occasional'. Those tenants who frequently boil only the amount of water they need in the kettle are considered 'frequent'.

Table 23: Behaviour changer related to kettle use

Do you only boil the amount of water you need when using the kettle?						
	Before Technical Intervention and Informational Intervention 2			After Technical Intervention and Informational Intervention 2		
Sample Group	Frequent	Occasional	Never / Very Rarely	Frequent	Occasional	Never / Very Rarely
Exposed to Informational Intervention 2	10 (77%)	0	3 (23%)	11 (85%)	2 (15%)	0
Not exposed to Informational Intervention 2	7 (54%)	2 (15%)	4 (31%)	9 (69%)	1 (8%)	3 (23%)
Total	17 (65%)	2 (8%)	7 (27%)	20 (77%)	3 (12%)	3 (12%)

Description

Before the Technical Intervention and Informational Intervention 2, 17 (65%) tenants 'frequently' boiled only the amount of water that they needed when boiling the kettle, 2 (8%) did this 'occasionally' and 7 (27%) boiled more than they needed. After the Technical Intervention and Informational Intervention 2, 20 (77%) tenants 'frequently' boiled only the amount of water they needed in the kettle, 3 (12%) did this 'occasionally' and 3 (12%) did this 'never/rarely'. In general there was a slight trend towards changing behaviour and 4 tenants who 'never/rarely' engaged in this behaviour did so 'frequently' or 'occasionally' after the Technical Intervention and Informational Intervention 2.

Before the Technical Intervention and Informational Intervention 2, the group that was exposed to Informational Intervention 2 engaged in this behaviour more 'frequently' than the other group. After the Technical Intervention and Informational Intervention 2 both groups experienced a slight shift towards 'occasionally' or 'frequently' engaging in this behaviour, but more tenants in the group exposed to Informational Intervention 2 changed behaviour from 'never/rarely' conducting the behaviour to 'occasionally' or 'frequently' conducting the behaviour.

Discussion

With regards to this behaviour tenants had no 'direct interaction' or 'indirect interaction' (see 5.3.1) with any technologies deployed as part of the Technical Intervention, therefore the slight change in behaviour may be attributed to Informational Intervention 2. The group exposed to Informational Intervention 2 had more tenants 'frequently' or 'occasionally' conducting the behaviour after the Technical Intervention and Informational Intervention 2, than the other group and this may be due to the impact of Informational Intervention 2, possibly in addition to

researcher impact from interviews (Informational Intervention 1). However, some tenants may have responded slightly differently to the question in the second interview, changed because of circumstances (e.g. more people in the household drinking hot drinks) or change in technology, (e.g. one tenant started using a 'one-cup' hot drink maker rather than the kettle and thus switched from 'occasionally' to 'frequently' engaging in the behaviour.

Tenants who were already engaged in the behaviour stated reasons such as convenience as the kettle was quicker to boil with less water in, because they had heard from the media that it saved energy, or because it was something they had always done because it was parental influence or common sense to them to put in only the amount needed. Those tenants who 'occasionally' engaged in the behaviour said that sometimes they would do this themselves when having hot drinks, but needed to boil larger amounts of water for very young children (for bottle sterilisation or heating contents of it). Some tenants who 'occasionally' or 'never/rarely' engaged in the behaviour stated that this was because the amount of people in the household and/or visitors, requiring hot drinks was unpredictable, thus it was more convenient to fill the kettle.

Patterns of Behaviour Related to Energy Use

- There was no significant impact on this behaviour due to the Technical Intervention.

- Marginal changes in behaviour may be linked to both Informational Intervention 1 and Informational Intervention 2.

- Tenants may have changed behaviours related to energy use when using the kettle, because they were motivated to save energy and were provided with knowledge and skill of how to do this.

- Tenants may have changed behaviours related to energy use because the behaviour also was convenient (i.e. kettle takes less time to boil when holding less water).

5.2.4.4   Fill your washing machine and keep temperatures low

Context

Tenants who said that they always used low temperatures (40°C or less) were recorded as 'frequent', tenants who used low temperatures, but also used higher temperatures (above 40°C) were recorded as 'occasional' and tenants who never had a full load or never used low temperatures were recorded as 'never/very rarely'.

Table 24: Behaviour Change Related to Washing Machine Use

Do you fill your washing machine and keep temperatures low?						
	Before Technical Intervention and Informational Intervention 2			After Technical Intervention and Informational Intervention 2		
Sample Group	Frequent	Occasional	Never / Very Rarely	Frequent	Occasional	Never / Very Rarely
Exposed to Informational Intervention 2	12 (92%)	1 (8%)	0	12 (92%)	1 (8%)	0
Not exposed to Informational Intervention 2	10 (77%)	3 (23%)	0	7 (54%)	5 (38%)	1 (8%)
Total	22 (85%)	4 (15%)	0	19 (73%)	6 (23%)	1 (4%)

Description

After the Technical Intervention and Informational Intervention 2 there was a slight shift towards 'occasionally' engaging in the behaviour in the group who were not exposed to Informational Intervention 2. Two tenants changed behaviour to engage in this behaviour 'occasionally' and one 'never/rarely'.

Discussion

With regards to this behaviour tenants had no 'direct interaction' or 'indirect interaction' (see 5.3.1) with any technologies deployed as part of the Technical Intervention. Informational Intervention 1 and Informational Intervention 2 do not appear to have had an impact on this behaviour. The most likely cause of changes in this behaviour related to the introduction of new born babies into the household within the 12 month period between baseline interviews and follow up interviews. Tenants in the group not exposed to Informational Intervention 2, reported that caring for an infant required higher temperatures to be used in the washing machine, with washes without full loads due to more frequent cleaning requirements and more soiled clothing. Other tenants who 'occasionally' use higher temperatures all reported to have younger children in the household.

Patterns of Behaviour Related to Energy Use

- There was no significant impact on this behaviour due to the Technical Intervention or Informational Intervention 2.

- Changes in behaviour were linked to external circumstances related to washing requirements for infants.

5.2.4.5   Turn off unnecessary lights around the house

Context

Tenants who stated that they frequently switched off lights around the home were recorded as 'frequent'. Tenants who stated that they occasionally left lights on were recorded as 'occasional' and those tenants who reported that they regularly left lights on unnecessarily were recorded as 'never/very rarely' engaging in this behaviour.

A small number of tenants do leave lights on when they are not occupying parts of the house or when they are sleeping, but as this is for security reasons or for the purpose of young children. This use of lights is considered necessary and it is therefore recorded as 'frequent'. If tenants state that they occasionally, never or very rarely, switch off unnecessary lights (i.e. they are not providing a useful purpose), tenants are recorded as an 'occasionally' or 'never/ very rarely' engaging in this behaviour.

Table 25: Behaviour change related to light use

Do you turn off unnecessary lights around the house?						
	Before Technical Intervention and Informational Intervention 2			After Technical Intervention and Informational Intervention 2		
Sample Group	Frequent	Occasional	Never / Very Rarely	Frequent	Occasional	Never / Very Rarely
Exposed to Informational Intervention 2	13 (100%)	0	0	13 (100%)	0	0
Not exposed to Informational Intervention 2	12 (92%)	1 (8%)	0	13 (100%)	0	0
Total	25 (96%)	1 (4%)	0	26 (100%)	0	0

Description

There was no significant change in this behaviour after the Technical Intervention and Informational Intervention 2. Before the interventions only one tenant stated that they 'occasionally' turned off unnecessary lights around the house. All 25 (96%) remaining tenants stated that they 'frequently' switched off unnecessary lights around the house. After the interventions all tenants reported that they 'frequently' switched off unnecessary lights around the house.

Discussion

With regards to this behaviour tenants had no 'direct interaction' or 'indirect interaction' (see 5.3.1) with any technologies deployed as part of the Technical Intervention. Informational Intervention 1 and Informational Intervention 2 do not appear to have had an impact on this behaviour. It is possible that the data gathering method may not have been targeted enough to detect the changes in behaviour related to lighting use, or some tenants may have occasionally left lights on, but responded that they 'frequently' turn lights off because it is what they think they do or what the researcher wants to hear. It is also possible that tenants already frequently turned off lights as this energy consumption is more visible in some cases and they are motivated to save energy. Therefore this behaviour did not change after the interventions because it was already an established behaviour. This would also align with tenant motivations to save energy reported in section 5.2.1.

Some tenants said that they switched off lights 'frequently', but could not control children's energy use and therefore some lights were left on. Some tenants do leave one or two lights on during the night for purposes of security or for their children.

Patterns of Behaviour Related to Energy Use

- There was no significant impact on this behaviour due to the Technical Intervention or Informational Intervention 2.

- Existing practice of this behaviour may be linked to the increased visibility of this type of energy use and aligned with motivations to save energy.

- The behaviour of others in the household may limit the tenant's ability to control energy use in association with lighting.

5.2.5 Other impacts of the interventions

5.2.5.1   Awareness and Use of Energy Efficient Appliances

Context

Tenants were asked about their awareness of energy efficient products (e.g. appliances with an 'A' rating in energy efficiency) and if this is something that they consider when purchasing new appliances.

Description and Discussion

A number of tenants reported that they consider the efficiency of new appliances purchased for their home. Many tenants stated that they had purchased new appliances immediately after the Technical Intervention and related refurbishment, stating that they had planned to do this in advance and were waiting for works to be completed before purchasing appliances. It is possible that the Technical Intervention created a context where tenants planned to purchase new appliances based around the timing of the Technical Intervention, purchasing a number of appliances at once where they may not have done in other circumstances. Some purchased more energy efficient models often investing more money in order to do so, whilst others purchased the most inexpensive models available regardless of energy efficiency. A number of tenants already had energy efficient appliances before the interventions.

Some tenants reported that they did not have knowledge of energy efficient appliances, or had not considered the energy efficiency of an electrical appliance when making a purchase, tending to purchase the cheapest models available, or purchase models for other reasons such as features or colour. Tenants reported that they had to purchase appliances while maintaining a restricted budget. It is worth noting that while the immediate cost for a more energy efficient appliance may indeed be higher than a less efficient appliance, the energy efficient appliance may, in the long term, provide higher energy savings and cost savings overall. If tenants had knowledge of these factors and had the financial resources available, they may be encouraged to purchase energy efficient appliances to maximise energy and cost savings.

Patterns of Behaviour Related to Energy Use

- The Technical Intervention and related refurbishment may have created a context in which more new appliances were purchased.

- Some tenants have limited knowledge of energy efficient appliances and this can be a barrier to take up.

- The take up of energy efficient appliances may be limited by the financial resources available to some tenants, who may purchase the most inexpensive model available to them, potentially not providing energy and financial savings in the long-term.

5.2.5.2   Awareness and Perception of Energy Costs

Context

Tenants were asked how they normally keep track of their energy use and the responses were coded accordingly.

Awareness of Energy Use and Costs

Tenants report that they 'look at bills' for awareness of their energy use, some are on a pre-payment scheme and 'look at pre-payment meters' for awareness of their energy use. Tenants have pre-payment meters either for gas or electric and at the same time are billed for gas or electric thus 'look at bills and pre-payment meter'. Financial costs are often the main way tenants maintain awareness of their energy use, if costs go up over a short period tenants generally attribute this to an increase in energy use.

Tenants that are on a pre-payment scheme regularly pay money 'as they go', money is registered on a card and used in the pre-payment meter, and this indicates how much money is remaining for the use of electricity or gas. Some tenants who are billed without pre-payment meters are on weekly budget schemes for their bill payments, so they are aware of how much their fuel costs fluctuate.

Table 26: Behaviour Change related to how tenants monitor their energy use

How do you normally keep track of your energy use?						
	Before Technical Intervention and Informational Intervention 2			After Technical Intervention and Informational Intervention 2		
Sample Group	Look at Bills	Look at Pre-payment Meters	Look at bills and pre-payment meter	Look at Bills	Look at Pre-payment Meters	Look at bills and pre-payment meter
Exposed to Informational Intervention 2	3 (23%)	7 (54%)	3 (23%)	4 (31%)	6 (46%)	3 (23%)
Not exposed to Informational Intervention 2	6 (46%)	7 (54%)	0	6 (46%)	7 (54%)	0
Total	9 (35%)	15 (58%)	2 (8%)	10 (38%)	13 (50%)	3 (12%)

More than half of the participants keep track of how much energy they are using by looking at remaining credit on pre-payment meters or by monitoring the weekly cost of energy and modifying behaviour when required (however energy cost does not always reflect use).

Tenants that use pre-payment meters generally appear to be more conscious of their energy use (judging by cost) than those people paying bills quarterly or monthly.

Perceived Changes in Energy Costs

A majority of tenants reported cost savings as a result of the interventions. However some tenants reported that costs had risen, which may be due to a number of reasons, for example: Increases in the costs of the tenant's energy tariff; tenants continuing use of fire for space heating (see 5.2.2.4) with increased running costs; tenants' beginning to use their heating more regularly, because they feel it is worth using after the Technical Intervention because it is more efficient and less energy and money is wasted on heating; having heating controls installed and programmed on a timed sequence (where heating would normally be either 'on' or 'off'), with tenants not understanding how to adjust the programme.

Patterns of Behaviour Related to Energy Use

- Within the group a majority of tenants use pre-payment meters or weekly budget plans for payment of bills and use this to judge energy use.

- Generally tenants who use pre-payment meters appear to be more conscious of their energy use and use the meter to plan energy use behaviour linked to available budgets at a particular time of the week.

- Increased fuel bills were reported by tenants after the interventions, which could be due to:
  - Increases in fuel tariff costs
  - Tenants continuing the behaviour of fire use for space heating with higher running costs than the previous gas fire
  - Tenants using heating more regularly because of a perception of improved efficiency due to the Technical Intervention and that less energy and money is wasted
  - Having heating controls installed and programmed on timed intervals where tenants would previously have had more control over the heating and may have used it less prior to the Technical Intervention.

5.3 Core Findings and Identification of Key Patterns

This section provides a summary of all the core findings and shows the relationship between the Technical Intervention (where applicable), 'patterns of behaviour related to energy use' and 'key patterns' of behaviour related to energy use. To begin, a summary of the significant impacts of Technical Intervention and Informational Interventions 1 and 2 is provided in addition to other related findings. Next the 'Core Findings Matrix' is presented and described, this shows (where applicable) the relationship between: the technology before the Technical Intervention; the associated behaviour before the Technical Intervention; the technology as part of the Technical Intervention; the 'template themes' and associated 'patterns of behaviour related to energy use', and finally; the 'key patterns' identified. 'Key patterns' of behaviour related to energy use are then highlighted.

5.3.1 Significant Impacts of the Technical Intervention

The synthesis of the 'patterns of behaviour related to energy use' within and across 'template themes' identified three distinctive groups in which 'patterns of behaviour related to energy use' fall into. These groups were distinguished by the type of interaction that tenants had with the technologies introduced as part of the Technical Intervention. There is reference below to 'template themes' in which a significant change in behaviour occurred and these fall into the three groups of technology interaction, which the researcher has identified as:

- 'Direct Interaction', the tenant interfaces with (or uses) the technology directly in their behaviour (i.e. behaviour interacts with the technology);

- 'Indirect Interaction', the tenant does not interface with (or use) the technology, but its introduction can create a significant change in behaviour due to the influence of the technology on the tenants structural or environmental context (i.e. technology influences behaviour);

- 'Negligible Interaction', the tenant does not interact with technologies of the Technical Intervention and no change in behaviour arises.

Building on the findings from Section 5.2, analysis of the following 'template themes' identified significant impacts on behaviour, and were considered to have a 'direct interaction' with the Technical Intervention:

- Programming central heating controls

- Using thermostatic control (majority of tenants changed behaviour)

- Using radiator controls (majority of tenants changed behaviour)

- Fire use for space heating

- Hot water use (bathing) (majority of tenants changed behaviour)

Analysis of the following 'template themes' identified significant impacts on behaviour, and were considered to have 'indirect interactions' with the Technical Intervention:

- Controlling drafts to maintain thermal comfort (majority of tenants changed behaviour)

- Close curtains at night to keep warm

- Wearing warmer clothing rather than turning on the heating or turning up the heating

Analysis of the following 'template themes' identified no significant impacts on behaviour, and were considered to have a 'negligible interaction' with the 'Technical Intervention':

- Carry out actions to cut down on gas use

- Carry out actions to cut down on electricity use

- Use energy saving light bulbs

- Switch off all appliances when not in use

- Boil only the amount of water needed when boiling the kettle

- Use full loads and low temperatures while using the washing machine

- Turn off any unnecessary lights

The strongest impacts on behaviours related to energy use appear to be associated with technologies installed as part of the Technical Intervention and represent cases of 'direct interaction' or 'indirect interaction'. For example, a case of 'direct

interaction' was the introduction of the thermostat controls which is likely to have created a significant change in behaviour because the technology (interacted with as part of the process of engaging in the behaviour) changed. A case of 'indirect interaction' was the change in the building fabric (such as double glazing) and introduction of effective central heating, which is likely to have led to a significant change in behaviour because the technology (*not* interacted with as part of the process of engaging in the behaviour) changed, and altered the environment and level of thermal comfort experienced by tenants. Thus, is likely to have led to a change in draft controlling behaviour.

No significant change in behaviours related to energy use were identified where tenants *did not* interact directly or indirectly with the technology introduced as part of the Technical Intervention and represent cases of 'negligible interaction'. For example, in the case of boiling only the amount of water needed when boiling the kettle, there was no interaction with the technology introduced as part of the Technical Intervention to engage in the behaviour and no change in structure of the technology in use, therefore there was 'negligible interaction' and is likely that behaviour change did not occur.

Thus it is suggested from this research that **significant behaviour change arises predominantly due to a change in technology, which changes the structures of daily behaviour (where interactions with technology occur) and therefore change the behaviour related to energy use itself.** However as will be discussed further in Section 5.4, these changes in behaviour due to technology may create potential savings in energy, thus enhancing the retrofit effectiveness or create potential increases in energy use, thus diminishing the retrofit effectiveness.

It can also be surmised that, due to the technologies' interaction and influence on behaviour related to energy use, any Informational Interventions delivered during future retrofit projects, should recognise this difference between a tenant's 'direct interaction', 'indirect interaction' and 'negligible interaction' with technology and its potential impact on behaviour. It is important that Informational Interventions target behaviours related to energy use, not only in a different way due to their varied relationship with the technology, but perhaps should prioritise behaviours related to energy use which interact with technologies introduced as part of the Technical Intervention. This is for two reasons, firstly, when structure changes it appears that this has an impact on behaviours related to energy use and if Informational

Interventions are to encourage energy saving behaviours, it seems prudent to deliver this Informational Intervention in parallel to the Technical Intervention in order to maximise energy saving behaviour through effective technology interaction. Secondly, as behaviours related to energy use are at risk of changing in unpredictable ways due to the Technical Intervention and associated change in technologies, it is important that Informational Interventions attempt to guide behaviours related to energy use and avoid behaviour change which may lead to potential increases in energy use, thus potentially diminishing the retrofit effectiveness.

5.3.2 Significant Impacts of the Informational Interventions

It was not clear if informational intervention 1 and 2 in combination, had an impact on energy use behaviours. Quantitative data may have helped to distinguish impacts of the two Informational Interventions, however due to a number of reasons, such as the difficulty obtaining quality from utility suppliers and quality and scope of the data, the option was not available.

Informational Intervention 1: researcher information

It was unavoidable to not have the involvement of Informational Intervention 1, because this was the influence of the researcher gathering data. It was not clear whether there was a distinguished impact arising from researcher information alone (from interviews which all tenants were subject to), or researcher information in combination with Informational Intervention 2: written and verbal guidance on energy saving behaviour. Originally it was the intention to observe the distinction between informational intervention 1 and 2 through the energy use utility data, in conjunction with a control group which would not receive Informational Intervention 1 or 2, however due to a number of reasons (see 4.3.2), such as the difficulty obtaining quality from utility suppliers and quality and scope of the data, this did not take place.

Informational Intervention 2: written and verbal guidance on energy saving behaviour

Table 27 below indicates tenant responses after the interventions when asked if the tenants felt they had more awareness about environmental issues as a result of the informational interventions. If tenants received written and verbal advice this was referred to in the question.

Table 27: General Change in Environmental Awareness after Interventions

Would you say you were more aware about energy use and the environment?			
	Same level of awareness	Slight increase in awareness	More awareness
Exposed to Informational Intervention 2	3 (23%)	5 (38%)	5 (38%)
Not exposed to Informational Intervention 2	9 (69%)	2 (15%)	2 (15%)
Total	12 (46%)	7 (27%)	7 (27%)

In comparing the two groups, there appears to be a significant impact on awareness with only 23% of tenants remaining at the same level of awareness. However this may be due to sampling bias, creating an existing positive attitude towards the project and their willingness to receive and take on board Informational Intervention 2. As the tenants who were provided with energy advice reported that they would like more information on energy use and the environment. Therefore reports of increased awareness may be due the enthusiasm of the group wanting advice and the fact that they were given information and then asked if this had an impact, and perhaps giving the socially acceptable answer.

Some tenants did report that Informational Intervention 1 along with Informational Intervention 2 had an impact on their awareness of environmental issues. Some of the influence on awareness may have been from external sources and should be acknowledged. For example, during the study the media profile of environmental issues increased considerably, partly due to international and domestic policy developments and events such as the *Copenhagen Climate Summit* in 2009. This was expressed in the group exposed to Informational Intervention 2 with 3 (23%) of the 5 (38%) tenants who reported they had more awareness –perceived that they were more aware, but also they perceived that everyone in the country was now more aware than they were in the previous year.

Informational Interventions appeared to be most effective when tenants had a limited knowledge of energy saving behaviours prior to Informational Intervention 2. Tenants reported that when they were already aware of energy saving behaviours Informational Intervention 2 had no impact because they did not learn anything they did not already know. Tenants who had gaps in their knowledge of energy saving behaviour, reported that they had gained knowledge as part of the informational interventions.

Although sometimes framed in an environmental protection rationale, Informational Intervention 2 may provide information which encourages or allows energy saving behaviour primarily due to other tenant priorities and motivations such as saving money (see section 5.2.1). Many tenants perceive a link between saving money and saving the environment and by conserving energy they are doing both.

Although it could not be identified if Informational Interventions had a significant impact on behaviour related to energy use, it is worth noting that knowledge and skills are a key factor impacting on energy use behaviour (see 5.4.1). This is so especially when this relates to the introduction of a new technology as part of the Technical Intervention which then requires the tenant's interaction to engage in behaviour to effectively use the technology. Knowledge and skills also influences behaviours that have a 'negligible interaction' with the technologies introduced as part of the Technical Intervention, such as using energy saving light bulbs or switching off appliances completely when not in use. With this in mind it is important to acknowledge the importance of knowledge and skills when delivering retrofit projects along with Informational Interventions so they specifically target not only guidance on specific technologies being introduced, but also on general behaviours related to energy use. This may assist the retrofit potential to improve energy efficiency and reduce carbon by encouraging the effective use of the introduced technologies and potentially reduce energy use and carbon emissions from other day to day activities.

5.3.3 Core Findings Matrix and Key Pattern Identification

Core Findings Matrix

Table 28 below is referred to as the 'Core Findings Matrix'. It shows the core findings of the research: 'patterns of behaviour related to energy use' and where they reccur within and across 'template themes'; 'key patterns'

The 'Core Findings Matrix' has the following columns of information (and related table headings):

- Section reference in the thesis

- Technology before Technical Intervention

- Associated behaviour before Technical Intervention

- Technology that is part of the Technical Intervention

- 'Template themes' and associated 'patterns of behaviour related to energy use'

- 'Key pattern' identified

Reading across each row of the 'Core Findings Matrix', relationships (whenever applicable) between the above aspects can be observed. The 'Core Findings Matrix' shows the 'patterns of behaviour related to energy use' that were identified within particular 'template themes' and indicates if this was associated with the Technical Intervention or not. Organising the 'patterns of behaviour related to energy use' in this way allows the identification of 'key patterns', where similar 'patterns of behaviour related to energy use' frequently occur, and indicate the types of 'template themes' in which they arise. 'Key pattern' identification will be discussed further in the section after table 28.

Table 28: Core Findings Matrix

	Table 28: Core Findings Matrix				
SEC-TION REF.	TECHNOLOGY BEFORE INTERVENTION *IF APPLICABLE*	ASSOCIATED BEHAVIOUR BEFORE INTERVENTION *IF APPLICABLE*	TECHNOLOGY AS PART OF TECHNICAL INTERVENTION *IF APPLICABLE*	TEMPLATE THEMES &PATTERNS OF BEHAVIOUR RELATED TO ENERGY USE	KEY PATTERN IDENTIFIED *IF APPLICABLE*
5.2.1				**Motivations and General Energy Use Behaviour Change**	
5.2.1.1				**Reported Motivations for Energy Saving Behaviour**	
				Tenants report that their primary motivation to save energy is to save money, but are also motivated to save energy to help minimise environmental impacts.	
5.2.1.2	No interventions	All tenants conducted behaviours to conserve gas and electricity	Technical Intervention in general	**General Gas and Electricity Consumption Behaviour**	
				All tenants conducted behaviours to conserve gas and electricity and there was no impact on behaviours as a result of the Technical Intervention or Informational Intervention 2.	
5.2.1.3			Technical Intervention in general	**Reported energy use behaviour**	
				A majority of tenants reported no change in energy use behaviour, (this suggests that tenants are not consciously aware of, or deliberate their energy use behaviours.)	
				Significantly more tenants reported changes in behaviour in the group that was exposed to Informational Intervention 2.	
5.2.2				**Space and water Heating**	
5.2.2.1	Back boiler heating system with no programmable controls, or controls in disrepair	A large majority of tenants did not programme central heating controls, due to not having access to the facility or not knowing how to use the facility	Installation of Central Heating System with Combi-boiler and digital control for temperature and timed programming	**Programming central heating controls**	
				The introduction of the heating controls technology from the Technical Intervention created a significant change in the behaviour of tenants to actively programme their central heating controls.	Technical Intervention Influences Behaviour
				A significant number of tenants did not change behaviours to actively programme their central heating controls, due to the following reasons: 1) Tenants did not understand how to programme the central heating controls;	Access to Knowledge and Skills Influences Behaviour
				2) Tenants manually switched the hot water and/or central heating on or off at the combi-boiler controls, because they wanted control of energy use for hot water and/or central heating, to avoid energy use at timed intervals when they did not wish to use it, or when it was not required;	

Table 28: Core Findings Matrix					
SEC-TION REF.	TECHNOLOGY BEFORE INTERVENTION *IF APPLICABLE*	ASSOCIATED BEHAVIOUR BEFORE INTERVENTION *IF APPLICABLE*	TECHNOLOGY AS PART OF TECHNICAL INTERVENTION *IF APPLICABLE*	TEMPLATE THEMES &PATTERNS OF BEHAVIOUR RELATED TO ENERGY USE	KEY PATTERN IDENTIFIED *IF APPLICABLE*
				3) Tenants manually switched (as above), due to a habit formed through previous use of back boiler.	Habit Influences Energy Use Behaviour
				In the context of social housing it is unclear if the behaviour of manual switching conserves more energy, than the behaviour of programming central heating controls.	
5.2.2.2	No thermostatic control.	All tenants had no access to a facility to control temperatures in their homes'	Installation of digital control for temperature and timed programming.	**Use of thermostatic control**	
				The introduction of the heating controls technology from the Technical Intervention created a significant change in behaviour in a majority of tenants. Tenants used the thermostatic controls to change temperatures to suit their needs.	Technical Intervention Influences Behaviour
				A majority of tenants kept thermostat settings at 20˚C or below.	
				Tenants who used thermostat settings above 20˚C, used thermostat settings at the slightly higher settings of 21-22˚C.	
				Tenants changed behaviours to use technology and conduct energy saving behaviour, because they were motivated to save energy and had knowledge and skill of how to do this.	Access to Knowledge and Skills Influences Behaviour
				Thermostatic controls were simpler to use in comparison with the controls to programme central heating to come on at timed intervals and this may be a reason why tenants changed behaviours to use this technology.	
				Two tenants from the group that were not exposed to Informational Intervention 2 were unaware of the thermostatic settings that they use and these cases may indicate the importance of training or guidance on thermostat controls.	Access to Knowledge and Skills Influences Behaviour
				There is a potential issue with the location of the central heating controls, in which the thermostat is contained due to the fluctuation of temperature of its location, not always reflecting the remaining rooms of homes.	Quality of Technical Intervention influences behaviour
5.2.2.3	No thermostatic radiator controls	All tenants had no access to a facility to control radiator temperatures in their homes'	Installation of radiators with thermostatic radiator controls	**Use of radiator controls**	
				The introduction of the radiator control technology from the Technical Intervention created a significant change in behaviour in a majority of tenants.	Technical Intervention Influences Behaviour
				Radiator controls were simpler to use in comparison with the controls to programme central heating to come on at timed intervals and this may be a reason why tenants changed behaviours to effectively use this facility.	

Table 28: Core Findings Matrix					
SEC-TION REF.	TECHNOLOGY BEFORE INTERVENTION *IF APPLICABLE*	ASSOCIATED BEHAVIOUR BEFORE INTERVENTION *IF APPLICABLE*	TECHNOLOGY AS PART OF TECHNICAL INTERVENTION *IF APPLICABLE*	TEMPLATE THEMES &PATTERNS OF BEHAVIOUR RELATED TO ENERGY USE	KEY PATTERN IDENTIFIED *IF APPLICABLE*
				Tenants who did not change behaviour reported this was because of being unaware of them, not understanding how to use them or for what reason and/or leaving them on installation settings.	Access to Knowledge and Skills Influences Behaviour
5.2.2.4	Gas fire	All tenants used the gas fire as a source of heat due to ineffective central heating.	Installation of (focal point) electric fire, with guidance to tenants to use central heating for space heating.	**Fire use for space heating**	
				The replacement of the gas fire with an electric fire (in conjunction with central heating) technology from the Technical Intervention created a significant change in behaviour in more than half of tenants.	Technical Intervention Influences Behaviour
				The communication of information was a factor which encouraged the change in behaviour in addition to the introduced central heating as an alternative means of space heating.	Access to Knowledge and Skills Influences Behaviour
				Tenants did not change behaviours due to being unaware or unclear on the most efficient way to use space heating.	Access to Knowledge and Skills Influences Behaviour
				A number of tenants stated a preference for using a fire for space heating instead of the central heating and nearly half of the tenants did not change behaviours and continued to use the electric fire.	Habit Influences Energy Use Behaviour
				Some tenants regretted having the electric fire installed and would like to have their gas fire back.	Habit Influences Energy Use Behaviour
				Tenants did not change behaviours because of perceptions and routines developed prior to the interventions which were continued afterwards.	Habit Influences Energy Use Behaviour
				Some tenants initially used the electric fire but then stopped using it because it was ineffective and costly compared to the gas fire.	
5.2.2.5	Baths with small number of electric showers, back boiler takes hours to heat water.	A majority of tenants only took baths and did this infrequently and conservatively (e.g. sharing bath water) in order to save energy and	Installation of mains fed showers providing instant hot water from combi-boiler.	**5.2.3.5 Hot water use (bathing)**	
				The installation of the mains fed shower technology as part of the Technical Intervention created a significant change in behaviour in almost half of the tenants.	Technical Intervention Influences Behaviour
				Some tenants perceived the shower to save more energy than having a bath and thus changed behaviour due to motivations to saving energy.	Access to Knowledge and Skills Influences Behaviour

SEC-TION REF.	TECHNOLOGY BEFORE INTERVENTION *IF APPLICABLE*	ASSOCIATED BEHAVIOUR BEFORE INTERVENTION *IF APPLICABLE*	TECHNOLOGY AS PART OF TECHNICAL INTERVENTION *IF APPLICABLE*	TEMPLATE THEMES &PATTERNS OF BEHAVIOUR RELATED TO ENERGY USE	KEY PATTERN IDENTIFIED *IF APPLICABLE*
Table 28: Core Findings Matrix					
		due to inconvenience of long hot water heating period.		Tenants used hot water more frequently, increasing the number of showers and in some cases baths after the Technical Intervention due to the convenience of the combi-boiler rather than the back boiler.	Convenience of Technology Influences Behaviour
				Some tenants took showers instead of baths because of the increased convenience and time saving compared to using the bath.	Convenience of Technology Influences Behaviour
				Some tenants were unclear on which type of bathing consumed the most energy.	Access to Knowledge and Skills Influences Behaviour
				Some tenants take baths as this provides a warmer more comfortable experience than showers and are willing to use more energy for this experience.	Thermal Comfort influences behaviour
				Some tenants continued the behaviour of having baths because they liked having baths.	Habit Influences Energy Use Behaviour
				Continued behaviours of using the bath instead of the shower may be linked to routines when the house was cold before the Technical Intervention, however some tenants did say bathrooms were still cold.	Habit Influences Energy Use Behaviour
5.2.3				**Controlling Drafts and Maintaining Thermal Comfort**	
5.2.3.1	Single glazed windows and wooden doors with significant drafts. Ventilation brick for gas fire which created drafts.	A majority of tenants attempted to control drafts. Some tenants did not attempt to control drafts as they felt it was overwhelming and too time consuming.	Installation of PVC Double glazed windows and doors	**Control Drafts in your home to stop heat escaping**	
				The installation of the external doors and double glazed windows technology as part of the Technical Intervention created a significant change in behaviour in almost half of the tenants.	Technical Intervention Influences Behaviour
				This particular change in behaviour may represent example of the Technical Intervention influencing behaviour to be less conservative of energy than before Technical Intervention.	Technical Intervention Influences Behaviour
				The installation double glazed windows and doors led to the experience improved thermal comfort and some tenants no longer felt the need to control drafts.	Thermal Comfort Influences Behaviour
				Just under half of tenants continued to experience drafts, which was likely to be due to inadequate attention to air tightness in the retrofit process and therefore continued to conduct behaviours to control drafts.	Quality of Technical Intervention influences behaviour

SEC-TION REF.	TECHNOLOGY BEFORE INTERVENTION *IF APPLICABLE*	ASSOCIATED BEHAVIOUR BEFORE INTERVENTION *IF APPLICABLE*	TECHNOLOGY AS PART OF TECHNICAL INTERVENTION *IF APPLICABLE*	TEMPLATE THEMES &PATTERNS OF BEHAVIOUR RELATED TO ENERGY USE	KEY PATTERN IDENTIFIED *IF APPLICABLE*
Table 28: Core Findings Matrix					
				The significant difference in draft controlling behaviour between the two sample groups exposed or not exposed to Informational Intervention 2 is due to tenants in one of the particular groups, still experiencing drafts and thus controlling them, rather than any informational impact.	Quality of Technical Intervention influences behaviour
5.2.3.2	Relates to the same technology pre-intervention as 5.2.3.1	Relates to the same technology associated behaviour pre-intervention as 5.2.3.1	Relates to the same technical intervention as 5.2.3.1	**Close curtains at night to keep the heat in**	
				The installation of the external doors and double glazed windows technology as part of the Technical Intervention created a marginal change in behaviour.	Technical Intervention Influences Behaviour
				This particular change in behaviour may represent example of the Technical Intervention influencing behaviour to be less conservative of energy than before Technical Intervention.	Technical Intervention Influences Behaviour
				The significant difference in draft controlling behaviour between the two sample groups exposed or not exposed to Informational Intervention 2 is due to tenants in one of the particular groups, still experiencing drafts and thus controlling them, rather than any informational impact.	Quality of Technical Intervention influences behaviour
				Changes in behaviour may also be linked to external circumstances, such as not having curtains up temporarily during and post retrofit.	External circumstances influence behaviour
5.2.4.3	Relates to the same technology pre-intervention as 5.2.3.1	Relates to the same technology associated behaviour pre-intervention as 5.2.3.1	Relates to the same technical intervention as 5.2.3.1	**Put on warm clothing rather than turn heating up**	
				The Technical Intervention of external doors, double glazed windows technology and effective central heating created a significant change in behaviour with nearly quarter of all tenant wearing warmer clothing occasionally rather than frequently.	Technical Intervention Influences Behaviour
				This particular change in behaviour may represent example of the Technical Intervention influencing behaviour to be less conservative of energy than before the Technical Intervention.	Technical Intervention Influences Behaviour
				The Technical Intervention of external doors, double glazed windows technology and effective central heating improved the level of thermal comfort for tenants. This is likely to have impacted on the behaviour to wear warmer clothing less frequently.	Thermal Comfort influences behaviour
				Tenants with young children reported that they wear warmer clothing when children are not in the house and avoid using the heating. When children are in the house tenants use central heating and/or fires for the warmth of children and cease to use extra clothing for themselves.	

SEC-TION REF.	TECHNOLOGY BEFORE INTERVENTION *IF APPLICABLE*	ASSOCIATED BEHAVIOUR BEFORE INTERVENTION *IF APPLICABLE*	TECHNOLOGY AS PART OF TECHNICAL INTERVENTION *IF APPLICABLE*	TEMPLATE THEMES &PATTERNS OF BEHAVIOUR RELATED TO ENERGY USE	KEY PATTERN IDENTIFIED *IF APPLICABLE*
Table 28: Core Findings Matrix					
5.2.5				**Electrical Appliances and Lighting**	
5.2.5.1				**Use energy saving light bulbs**	
				There was no significant impact on this behaviour due to retrofit or Informational Intervention 2.	
				Changes in behaviour were linked to external circumstances.	External circumstances influence behaviour
				A majority of tenants did not use energy saving light bulbs widely in their home due to: 1) Negative perceptions of the technology (e.g. preference for traditional design)	
				2) Knowledge and awareness of recent product designs which may meet tenant needs (e.g. range of fittings, speed of activation and light quality).	Access to Knowledge and Skills Influences Behaviour
				Perceptions of the credibility of energy saving light bulb technologies can be impacted by tenants being introduced to the technology via low-cost or free early models of a technology.	
5.2.5.2				**Turn off all appliances completely when not in use**	
				There was no significant impact on this behaviour due to the Technical Intervention.	
				Barriers to switching off appliances completely when not in were due to: 1) Convenience reasons (e.g. time taken to switch appliances on, access to sockets)	Convenience of Technology Influences Behaviour
				2) Limited knowledge of this energy use behaviour in connection with certain appliances (e.g. concern of damage to appliances from switching on and off at the mains).	Access to Knowledge and Skills Influences Behaviour
5.2.5.3				**Boil only the amount of water you need when boiling the kettle**	
				There was no significant impact on this behaviour due to the Technical Intervention.	
				Marginal changes in behaviour may be linked to both Informational Intervention 1 and 2.	

Table 28: Core Findings Matrix					
SEC-TION REF.	TECHNOLOGY BEFORE INTERVENTION *IF APPLICABLE*	ASSOCIATED BEHAVIOUR BEFORE INTERVENTION *IF APPLICABLE*	TECHNOLOGY AS PART OF TECHNICAL INTERVENTION *IF APPLICABLE*	TEMPLATE THEMES &PATTERNS OF BEHAVIOUR RELATED TO ENERGY USE	KEY PATTERN IDENTIFIED *IF APPLICABLE*
				Tenants may have changed energy use behaviours when using the kettle, because they were motivated to save energy and were provided with knowledge and skill of how to do this.	Access to Knowledge and Skills Influences Behaviour
				Tenants may have changed energy use behaviours because the behaviour also was convenient (i.e. kettle boils quicker)	Convenience of Technology Influences Behaviour
5.4.5.4				**Fill your washing machine and keep temperatures low**	
				There was no significant impact on this behaviour due to the Technical Intervention or Informational Intervention 2.	
				Changes in behaviour were linked to external circumstances related to washing requirements for infants.	External circumstances influence behaviour
5.2.5.5				**Turn off unnecessary lights around the house**	
				There was no significant impact on this behaviour due to technical or informational interventions.	
				Existing practice of this behaviour may be linked to the increased visibility of this type of energy use and aligned with motivations to save energy.	
				The behaviour of others in the household may limit the tenant's ability to control energy use in association with lighting.	
5.2.6				**Other Impacts of the interventions**	
5.2.6.1				**Awareness and use of energy efficient appliances**	
				The Technical Intervention and related refurbishment may have created a context in which more new appliances were purchased.	External circumstances influence behaviour
				Some tenants have limited knowledge of energy efficient appliances and this is a barrier to take up	Access to Knowledge and Skills Influences Behaviour
				The uptake of energy efficient appliances is limited by the budgets of some tenants who prefer to choose the cheapest product available, which may not always provide energy and financial savings in the long run.	External circumstances influence behaviour

Table 28: Core Findings Matrix					
SEC-TION REF.	TECHNOLOGY BEFORE INTERVENTION *IF APPLICABLE*	ASSOCIATED BEHAVIOUR BEFORE INTERVENTION *IF APPLICABLE*	TECHNOLOGY AS PART OF TECHNICAL INTERVENTION *IF APPLICABLE*	TEMPLATE THEMES &PATTERNS OF BEHAVIOUR RELATED TO ENERGY USE	KEY PATTERN IDENTIFIED *IF APPLICABLE*
5.2.6.2				**Perceived impacts on energy costs**	
				Within the group a majority of tenants use pre-payment meters or weekly budget plans to for payment of bills and use this to judge energy use.	
				Generally tenants who use pre-payment meters appear to be more conscious of their energy use and use the meter to plan energy use behaviour linked to available budgets at a particular time of the week.	Access to Knowledge and Skills Influences Behaviour
				Increased fuel bills were reported by tenants after the interventions, which could be due to: 1) Increases in fuel tariff costs	
				2) Tenants continuing the behaviour of fire use for space heating with higher running costs than the previous gas fire	
				3) Tenants using heating more regularly because of a decreased perception of waste because of the Technical Intervention	
				4) Having heating controls installed and programmed on timed intervals where tenants would previously have had more control over the heating	

Key Patterns Identified

The 'Core Findings Matrix' (table 28) above shows the various 'patterns of behaviour related to energy use' identified through data analysis of the 'template themes'. 'Key patterns' of behaviour related to energy use were identified where 'patterns of behaviour related to energy use' recurred within and across the 'themes' of the analysis 'template'. Similar 'patterns of behaviour related to energy use', repeated within the findings and where this was the case it was considered a 'key pattern'. For example, the 'key pattern': 'Access to Knowledge and Skills Influences Behaviour' can be found 13 times within template themes and across different template themes, thus it is considered a 'key pattern'.

'Key patterns' are labelled with a broader title which represents the recurring 'pattern of behaviour related to energy use 'in a collective sense and this is also colour coded. Within these 'key patterns' the number of similar 'patterns of behaviour related to energy use' which recur within and across themes are counted, and when higher in number are considered more frequent, and thus the 'key pattern' is considered more significant. Based on the frequency of similar 'patterns of behaviour related to energy use' the 'key patterns' are ranked in order of significance. Table 29 shows the 'key patterns' of behaviour related to energy use that were identified as part of the above synthesis and are ranked according to the frequency of recurrence of 'patterns of behaviour related to energy use'.

Table 29: Key Patterns Identified

Key Pattern	Frequency Energy Use Pattern Recurrence
Access to Knowledge and Skills Influences Behaviour	13
Technical Intervention Influences Behaviour	11
Habit Influences Energy Use Behaviour	6
External circumstances influence behaviour	5
Quality of technical intervention influences behaviour	4
Convenience of Technology Influences Behaviour	4
Thermal comfort influences behaviour	3

5.4 Discussion of Key Patterns

This section provides a discussion of each of the 'key patterns' identified in table 29. The 'key patterns' are described and examples of 'patterns of behaviour related to energy use' are used to aid the discussion in conjunction with references to the literature where appropriate.

As much of the focus of this research is to evaluate the impact of the Technical Intervention (or retrofit technologies) on behaviour related to energy use and to identify behaviour-related barriers to retrofit energy saving effectiveness, emphasis is given to the impact of technologies installed on behaviour related to energy use. The findings indicate that many of the impacts on behaviour related to energy use are associated with knowledge and skills access, the introduction of technology as part of the Technical Intervention, and the influence of habits.

Access to knowledge and skills is often required to change behaviour related to energy use to begin using energy efficient technologies introduced as part of the Technical Intervention, effectively or at all. The introduction of or change in the energy efficient technology through the Technical Intervention, influenced behaviour related to energy use considerably where behaviour 'directly interacted' with the technology. Habits formed from behaviours conducted before the Technical Intervention and may have prevented behaviours related to energy use from changing to begin using, or to effectively use introduced energy efficient technologies. Further 'key patterns' identified are also discussed below concerning their influence on behaviour, which are: external circumstances; quality of the technical intervention; convenience, and; thermal comfort.

Minimal impacts on behaviour were found to be due to the Informational Interventions as part the PhD research. Of the 'key patterns' discussed in this section, many relate to the reasons why behaviour related to energy use does or does not change as a result of the Technical Intervention. The main intention of the retrofit project is to improve energy efficiency, reducing energy use and carbon emissions. Thus, it is important to consider the causality behind cases where tenants' behaviour related to energy use changes, or does not change to utilise introduced technology, or to utilise it effectively. Indeed, also noting cases where introduced technology may change behaviour related to energy use to possibly *increase* energy use impacting on the energy saving potential of the retrofit project.

The role of theoretical perspectives in explaining the findings

As much of the focus of this research is to evaluate the impact of the Technical Intervention (or retrofit technologies) on behaviour related to energy use and to identify behaviour-related barriers to retrofit energy saving effectiveness, emphasis is given to the impact of technologies installed on behaviour related to energy use. This emphasis on the impact of technology on agency and an individual's behaviour in the context of a retrofit means that the findings are framed in a way in that they are better explained by theoretical perspectives from the social psychology paradigm, rather than that of Practice Theory.

For example, (as discussed in the below sections under the heading 'discussion in relation the literature') in the case of skills and knowledge, the psychology literature notes the importance of social conditions (such as skill and knowledge) along with structural changes, to support action (Krosnick and Smith, 1994. Psychological models such as the NOA (Vlek, et al., 1997) emphasise ability (which is grounded in knowledge and skills) and its impact on 'Perceived Behavioural Control'. In terms of explaining the impact of the Technical Intervention on energy use behaviour the discussion again draws on psychology literature by Midden et al., (2007) to explore technology's roles. The influence of habits on energy use behaviour is a psychologically framed concept so it is not surprising that here the psychology literature (Maio et al., 2007; Verplanken and Wood; Verplanken et al., 2008) is useful for explaining this key pattern.

Generally speaking the psychology literature provided a more suited explanation for the much of the key findings. As the very approach to the research was in response to Gentoo Group's questions was regarding energy use 'behaviour' with the approach focusing on individual actions in response to technology, it is likely that the psychology literature was more suited to explaining the findings. Nevertheless, Practice Theory was particularly useful for illuminating some key patterns, for example insight into convenience (Hand et al., 2005) and in relation to the Technical Intervention's impact on behaviour, the combination of elements which include 'materials', 'competencies' and 'conventions' which can allow practices to form (Shove, 2009b). Practice Theory provides a valuable perspective for understanding the influences on behaviour (or to use the disciplines term, 'practices') from the interactions between lifestyles and the systems of provision. It highlights the importance of understanding human actions from a psychological perspective, but

also to include broader social factors and elements existing in time and space which can form and human actions.

5.4.1 Access to Knowledge and Skills Influences Behaviour

As indicated by the 'Core Findings Matrix' (table 28) and the 'key patterns identified' (table 29) this 'pattern of behaviour related to energy use' recurred thirteen times across ten 'template themes'. This 'key pattern' describes behaviour related to energy use being impacted by a tenant's access to knowledge or skills. Thus limited access to related knowledge or skills may prevent change in behaviour related to energy use to use or effectively use the introduced technology as part of the Technical Intervention, or prevent energy saving behaviour. There are also cases where a tenant is sufficiently motivated to conduct energy saving behaviours and the access to knowledge and skills allows changes in behaviour related to energy use to take place.

Little Access to Knowledge and Skills Prevents Energy Use Behaviour Change

This research focuses on the impacts of the Technical Intervention on behaviour related to energy use, but it is equally important to note where no impacts occur. If technologies are retrofitted to a home with the intention of improving energy efficiency and reducing carbon emissions, some of these technologies need to be used effectively (or even used at all) in order to yield the benefits of the technology, allowing its functional and purpose be properly achieved. If people don't know how to use a technology properly (or at all), it will not assist the achievement of the retrofit goals of energy efficiency and carbon reduction, which is why it was installed in the first place. Essentially tenants need knowledge and skills if they are to change behaviours to use retrofitted technologies to maximum effect and to engage in energy saving behaviours.

This 'key pattern' of 'access to knowledge and skills' was linked with 'patterns of energy use behaviour' that had a 'direct interaction' with technologies introduced as part of the Technical Intervention, which is important to note for retrofit planners if they are to maximise the effectiveness of retrofits. This 'key pattern' was not linked with 'patterns of behaviour related to energy use' associated with controlling drafts and maintaining thermal comfort, implying that tenants already have the knowledge and skills to control drafts and maintain thermal comfort. However, this 'key pattern' was linked to 'patterns of energy use behaviour' that had 'negligible interaction' with

technologies that were part of the Technical Intervention (e.g. switching off appliances when not in use; use energy saving light bulbs). This indicates that knowledge and skills also have an influence on behaviours related to energy use which are not associated with the Technical Intervention. Nevertheless it is important to acknowledge this because these behaviours related to energy use still effect energy consumption and carbon emissions. Indeed, these behaviours related to energy use not interacting with introduced technologies also need attention when considering retrofit implementation, and related communication programmes to inform tenants on technology use and energy saving behaviour.

In relation to energy use behaviours which were not associated with the Technical Intervention. The findings indicate that up to date knowledge on technology was an important factor in energy use behaviour change to using energy saving light bulbs. This was because tenants' perceptions were based on older energy saving light bulb designs, which did not provide light for their needs and/or had the correct fittings or 'look'. However, in the case of those tenants who have pre-payment meters displaying the amount of energy remaining in terms of unit cost, this access to knowledge and information generally encourages energy use behaviour to conserve electricity and gas.

Access to Knowledge and Skills Allows Energy use Behaviour Change

Tenants often reported that they did not change behaviours to use a technology introduced as part of the technical intervention because they did not have the knowledge or skills to use the technology effectively or were not aware of it, or of its purpose. This was most notably observed in the case with the programmable heating controls and to a lesser extent the thermostatic controls and radiator controls. With regards to fire use for space heating, some tenants did not change behaviours to use the central heating because they were unaware of the most effective ways to heat the home. Thus, based on their perceptions tenants continued to use the fire for space heating, where central heating could heat only this room more efficiently with the correct use of radiator controls.

With regard to the above energy use behaviours, the absence of knowledge and skills prevented behaviour change to effectively use retrofitted technologies. On the other hand, evidence also showed how access to knowledge and skills would allow particular energy use behaviours. For example, a number of tenants who changed behaviour to use the central heating for space heating instead of the fire said they

did this because of the information provided by Gentoo Group. Some of the tenants who reported that they had not received this information, also continued to use the fire for space heating.

Simplicity of technology and ease of understanding and use may impact on behaviour change to use the technology introduced as part of the technical intervention. In the cases where technology could be easily operated, for example the thermostatic controls having buttons for 'up' (for higher temperatures) and 'down' (for lower temperatures), tenants changed energy use behaviours to effectively use technology in an energy saving way.

For example, a majority of tenants changed energy use behaviours to begin using the thermostatic control to change temperatures, using the technology to maintain temperatures at 20 or below and thus save energy. Tenants reported that they found the temperature controls simple to use and it was generally recognised that higher temperatures used more energy. Also, some tenants reported that they were aware that showers used less energy than baths and as they found showers simple to use, they changed energy use behaviour from having baths to having showers. Therefore, it appears that using these technologies did not require significant prior knowledge and skills and thus tenants changed energy use behaviour to begin using the these technologies. This suggests that knowledge and skills are an important in the process of delivering a Technical Intervention in order for occupants to change energy use behaviours to effectively utilise them. Also the design of technologies and their simplicity of use or understanding may also ease the burden of requiring this knowledge and understanding in order to use technologies effectively.

Motivation in conjunction with knowledge and skills, influences behaviour

Tenants in general had a motivation towards saving energy, primarily in order to save money. However, the technology available may have prevented a change in energy use behaviour towards saving energy and thus the introduction of technology can influence behaviour (see 5.4.2). Before the technical intervention barriers to achieving energy saving behaviours were structural and technological (e.g. inefficient central heating, no double glazing). The technical intervention removed some of these barriers introducing energy efficient technologies so that tenants could potentially act on their motivations and conduct energy saving behaviours. However, the findings show that knowledge and skills are pivotal in preventing or allowing energy use behaviour change to take place, even when tenants are

motivated and the introduced technologies allow energy saving behaviours to take place.

Discussion in Relation to the Literature

The literature supports the finding that access to knowledge and skills can influence energy use behaviour. In terms of either preventing, or allowing, behaviour change to use a technology (or use it effectively), and in the case of other energy use behaviours.

Gill et al. (2010) and Stevenson and Rijal (2010) have emphasised that energy efficiency retrofits are not always effective due to the behaviour of the occupant, as there is often a lack of training or misunderstanding of how to use retrofit technologies to maximise the efficiency and benefits they provide.

In Practice Theory a key element is considered to be 'competence' (the skills and knowledge to make equipment work), which work in unison with 'image' (the ideas of a practice being correct and normal) and 'material' (the physical infrastructure) which allows a practice to occur (Hand et al., 2005). In this sense it is not enough to simply provide the materials (or infrastructure) to change energy use behaviour, and have image (ideas or conventions) of such energy use behaviour, it is also critical for tenants to have competence (knowledge and skills) in using the newly introduced technology.

The Psychology literature has highlighted that attitudes occasionally only guide behaviour, and most commonly this is where attitudes are strong (e.g. important, based on experience and knowledge or certain) *and* where social and structural condition support action (Krosnick and Smith, 1994; Stern, 2000). Tenants have strong attitudes towards saving energy in order to save money. If structural changes (Technical Intervention), are accompanied by social changes (development of knowledge and skills to use technologies) to support action, energy use behaviours may change towards using technologies effectively and saving energy.

The rational choice model from the psychology literature argues that conservation based decisions can be influenced if consumers are provided with information relating to financial and performance advantages of alternative choices, enabling them to act accordingly (Jackson, 2005). As the finding that access to knowledge and skills can be an enabler or preventer of behaviour change, it could be argued

that the rational choice model may apply in the case of this key pattern. The provision of information on how to use technology, that it can save energy and money may provide some tenants with the rational choice to perform energy conserving behaviour. However, within this group the motivation to save energy mainly due to financial reasons has already been identified, so this 'rational choice' to behave in an energy saving due to financial advantages may be less relevant. The 'rational choice' has already been made and tenants already report intentions and associated behaviours to save energy. These tenants already have an attitude towards and motivation to save energy and the knowledge and skills may simply provide an avenue to act on such attitudes and motivations rather than rationalising choices.

This differs from being provided with the information relating to the financial and performance advantages and rationalising a course of action based on this information, perhaps this may be better suited to a socio-economic group who (in comparison) have less financial motivation to minimise energy use (i.e. groups that prioritise energy conservation for environmental reasons rather than due to significant financial constraints). Indeed, the environmental psychology literature related to environmental or conservation behaviour seems to focus on the problem of changing behaviour to conserve less energy for environmental reasons, where by the motivation to save energy is predominantly rationalised in environmental protection imperatives, rather than due to financial constraints. Perhaps this focus loses sight of the fact that groups may be low-impact and low-resource users because their financial constraints restrict their consumption. As such they don't possess the same consumption 'power' as other social groups, for which energy consumption is high because their relative financial flexibility allows the consumption of more energy. Therefore, in reference to the group tenants involved in this research (and similar socio-economic groups in social housing), the provision of knowledge and skills may be less about creating motivation to through rational choice, but to provide the knowledge and skills to create potential for tenants to act on these motivations.

Vlek et al's (1997), Needs Opportunities, Abilities (NOA) model shows how environmental factors can influence behaviour and shows clearly that focusing only on personal factors alone will not necessarily bring about behaviour change. This model emphasises the interaction between individual and society, and demonstrates the need for interventions aiming to change behaviour to work on multiple levels of

scale (Gatersleben and Vlek, 1998). Macro-societal factors determine the conditions of the individual's needs (e.g. energy efficient homes, thermal comfort), the opportunities and availability (e.g. Gentoo Group communication of retrofit availability) and, abilities (e.g. physical technologies which improve thermal comfort, knowledge and skills to use technologies). Essentially, tenants had needs for thermal comfort and energy efficiency to reduce costs, and an opportunity was provided in the form of taking part in the Retrofit Reality project. Physical technologies such as a combi-boiler and double glazed windows provided potential for behaviour change. However, the provision of information to assist cognitive understanding of ways of using technologies effectively to improve thermal comfort and save energy were reportedly less available. Therefore many tenants did not have the abilities (knowledge and skills) related to the technologies, impacting on perceived behavioural control, and thus potential for behaviour change. Tenants often did not know how to begin using technologies, to effectively use them, or were not aware of the technologies existence or purpose.

The same principle of the NOA also applies to energy saving behaviour not directly or indirectly interacting with the introduced technologies, such as using energy saving light bulbs. If tenants don't have the abilities, such as knowledge and skills relating to the types of technology available for their needs, this impacts on 'Perceived Behavioural Control' and intention, preventing energy use behaviour change.

5.4.2 Technical Intervention Influences Behaviour

As indicated by the 'Core Findings Matrix' (table 28) and the 'key patterns identified' (table 29) this energy use behaviour pattern occurred eleven times across template themes and within template themes. This 'key pattern' can be described as a change in energy use behaviour as a result of technologies installed as part of the technical intervention. Here the technology introduced changes to the energy use behaviour of tenants when because behaviour involves (or begins to involve) a form of interaction with such technology. The change in environment or structure directly (behaviour involves using the technology) or indirectly (behaviour is influenced by the technologies properties) influences the way tenant uses energy. Often the introduction of (or change in) technology allows tenants to behave in a way which they were unable to due to the infrastructure available, therefore in some cases tenants begin using the technology.

Space and Water Heating

Energy use behaviour template themes related to space and water heating are: *Programming central heating controls; Using thermostatic control; Using radiator controls; Fire use for space heating, and; Hot Water Use (Bathing).* All these energy use behaviour template themes involve the tenant directly interfacing (using) a technology (e.g. switching on a source of heat) which changes as part of the Technical Intervention. Thus technologies related to space and water heating are considered to have a 'Direct Interaction', i.e. the tenant interfaces with the technology directly in their behaviour (i.e. behaviour interacts with the technology);

The introduction of the programmable heating controls, thermostatic controls and radiator controls from the technical intervention created a significant change in the behaviour of tenants to begin using them to manage the use of heat in the home. Tenants changed behaviour to begin actively using these technologies where previously they had not, mainly due to not having access to the technology. Tenants changed behaviours to programme central heating controls so that heating came on at timed intervals where previously they had switched central heating on or of manually. Thermostatic controls and radiator controls were used to adjust or maintain temperatures in the home or as with the radiator controls manage the provision of heat in specific areas of the house. As with many of the energy use behaviour patterns discussed in this chapter, the use of heating and radiator controls involve interaction with technology. Tenants are in general motivated to save energy in order to save money (see 5.2.1) thus they wish to control energy use in order to achieve this. Therefore, when the technologies that are part of this interaction change or are introduced, this can change the way people use energy or enable new energy use behaviours.

Technology change as a trigger point for behaviour change also impacted on the energy use behaviour of fire use for space heating. Here, the replacement of the gas fire with an electric fire (in conjunction with new central heating) technology created a significant change in behaviour in more than half of tenants. Tenants changed behaviour to stop using the fire for space heating and began instead using the central heating. It is not certain why tenants changed behaviour in this way, however the impact of changing technology clearly had an influence as the introduction of new (and functional) central heating allowed access to a different and effective source of space heating. Indeed, according to tenant reports it appears that the level

of effectiveness of the fire and the central heating was switched as a process of the Technical Intervention. As such, the fire was more effective at providing heat before the retrofit and after became less effective, with the central heating functioning poorly (or not at all) before the Technical Intervention and functioning effectively afterwards. As tenants may be seeking the most effective means of accessing heat this change in technology effectiveness to achieve this goal may well have changed tenants' behaviour to begin using the central heating instead. Other factors may also have influenced this change in behaviour, such as tenants perceiving of electric fire running costs being higher and the verbal guidance that some tenants received from Gentoo Group and/or Informational Interventions 1 and 2. However, the key issue is that the change or introduction of space heating technology had an impact on tenant energy use behaviour. Therefore, consideration of the types and effectiveness of technologies is an important part of retrofit planning, as is the consideration of the way that these technologies change energy use behaviour and if such a change contributes to the retrofit goals of energy efficiency and carbon reduction.

In the case of hot water use for bathing the installation of the mains fed shower technology as part of the Technical Intervention created a significant change in behaviour in almost half of the tenants. Tenants changed behaviour to begin using showers to bathe more frequently instead of using baths. Similar to the above energy use behaviour patterns, this change in behaviour was ultimately made possible by the introduction and thus availability of the shower technology. The availability of the technology of the shower allowed this energy use behaviour to occur where it had in most cases not been possible. As will be discussed further in later sections discussing 'key patterns', the availability of the technology along with other motivators such as saving energy and convenience also influenced the causality in changing this energy use behaviour.

Controlling Drafts and Maintaining Thermal Comfort
Energy use behaviour template themes related to controlling drafts and maintaining thermal comfort are: *Control drafts in your home to stop heat escaping; Close curtains at night to keep the heat in; Put on warm clothing rather than turn the heating up.* All these energy use behaviour template themes involve the tenant's energy use behaviour being influenced by the technologies changes in the structural or environmental context. Thus energy use behaviour patterns related to controlling drafts and maintaining thermal comfort are impacted on by the 'Indirect Interaction' with the technology introduced as part of the technical intervention, because the

technology (e.g. central heating, double glazed windows and doors) influences behaviour by changing environment.

With regards to: *control drafts in your home to stop heat escaping,* the installation of the external doors and double glazed windows technology as part of the Technical Intervention created a significant change in behaviour in almost half of the tenants. These tenants reported that they had changed their behaviour to cease draft controlling behaviour because drafts had been reduced to a minimum and they no longer perceived it to be a problem. This is likely to be due to improved levels of thermal comfort, as tenants reported that the house was warmer, likely to be due to the improved double glazed windows, doors, insulation and central heating. Related to the energy use behaviour theme: *Close curtains at night to keep the heat in,* the installation of the external doors and double glazed windows technology as part of the Technical Intervention created a marginal change in behaviour. Tenants changed behaviours to stop using curtains and to only use blinds to control drafts. In reference to: *Put on warm clothing rather than turn the heating up,* the Technical Intervention of external doors, double glazed windows technology and effective central heating created a significant change in behaviour with nearly quarter of all tenant wearing warmer clothing occasionally rather than frequently.

In the case of all the above energy use behaviour patterns related to controlling drafts and maintaining comfort there was an 'Indirect Influence' of the technology, whereby temperatures were improved by the Technical Intervention of central heating and the thermal efficiency of the building (e.g. through double glazed windows, doors and insulation) which also reduced drafts. This made tenants feel more comfortable and thus they did not feel the need to control drafts as much or where warmer clothing as frequently rather than use the heating. This links to the later 'key pattern' discussed regarding the influence of thermal comfort on behaviour (5.4.7).

Discussion in Relation to the Literature

The literature supports the finding that the technical intervention (introduced technologies) can influence energy use behaviour, preventing, or allowing behaviour change to use technology (or use it effectively).

Midden et al., (2007) note that technology and behaviour are closely interwoven in many respects, and they have described four main roles that technology plays: as

intermediary, where the technology is a conduit between the behaviour an individual carries out to reach a goal and the use of natural resources (in this case energy derived mainly from the burning of fossil fuels) on the way to that goal; as *amplifier*, where the technology amplifies, enhances or extends the individuals goal attainment, with the side effect of increased resource consumption (energy use); as *determinant*, where the technology creates context or environment surrounding the individual, thus influencing or shaping behaviour through the technology's existence, and; as *promoter of environmentally significant behaviour,* where technology is specifically designed to promote behavioural choices leading to the conservation of natural resources, rather than with emphasis on the motivation of the end user, such as energy use feedback.

The introduction or change of technology though the technical intervention has, to one degree or another, demonstrated the former three technology roles related to consumption behaviour as described by Midden et al., (2007). None of the technologies are actual promoters of environmentally significant behaviour. These different roles can also be related to other 'key patterns' described later in the section, however these roles of technology are described here as they closely align with this particular 'key pattern' of the technical intervention influencing behaviour.

When technology acts as determinant it directly influences energy use behaviour. It is contextual technology that surrounds the individual and, and can either help or hinder conservation-related actions, but individuals may not be aware of this. Technology in the role of a determinant may channel or shape behaviour apart from people's motivation. The availability of a thermostatic control, for example, makes its use more likely, while the absence of it obstructs use drastically. The change in structure (environment), through the technical intervention leads to behaviour change in the context of a retrofit. However, it is not always clear whether the change in behaviour will lead to energy saving, carbon reduction or a reduction in fuel costs.

The introduction of the technology as an intermediary can allow behaviour changes. The introduction of the heating controls technology, to programme heating to come on at timed intervals and thermostatic controls to adjust temperatures created a significant change in the behaviour of tenants. The technology was introduced and therefore acted as an intermediary to tenants' goals to control heat in their homes,

as they were previously unable to achieve this mainly because the facility was not fitted or was not functioning. Many of the energy use behaviour patterns which relate to this key pattern demonstrate technology as an intermediary where a tenant's goal, for example to improve their thermal comfort or bathe, is channelled through a particular technology as the tool for achieving that goal.

The Technical Intervention may change behaviours so that more energy is consumed, thus technology acts as an amplifier. For, example hot water consumption behaviour increased due to the introduction of a combi-boiler, creating access to instant and convenient hot water. Where technology serves as an amplifier, the tenant's use of a technology clearly enhances, extends, or amplifies their goal attainment. As a side effect, behaviour becomes more resource-consumptive as well. Thus, the amplifier role creates the basis for rebound effects, where efficiency gains are getting dissolved due to amplified consumption. For example, in the reported frequency of hot water use due to access to instant water-heating technology where the previous technology took time, limited the availability of hot water creating inconvenient, thus required more deliberation, planning and energy conservation behaviours.

The interplay between technology and behaviour has important policy implications. For example, the Government's Choice Architecture or 'Nudge' approach to behaviour change in regard to energy consumption, predominately focuses on encouraging the purchase of energy efficient or low carbon technologies to be used within or retrofitted in housing to reduce carbon dioxide emissions and improve energy efficiency. However, the technology which the public is being 'nudged' to purchase may not actually produce the desired carbon reduction or energy savings due to unanticipated outcomes from the interplay between behaviour and technology, such as amplification of energy use due to convenience. In this sense, careful application (e.g. research informed) of the 'Nudge' approach (if at all possible) may be required to ensure that the 'choice' that the public is being 'nudged' towards is actually going to contribute towards efforts to reduce carbon dioxide emissions and reduce energy use.

Returning to Vlek et al's (1997), Needs Opportunities, Abilities (NOA) model, with regards to this 'key pattern' the macro-societal factors noted in the model are, opportunities (retrofit availability) and abilities, similar to the knowledge and skills 'key pattern', but this time abilities are the actual physical technologies which are

introduced and impact on perceived behavioural control and prevent such behaviour change.

Practice Theory can again be referred to with regard to this 'key pattern', because the physical infrastructure or 'materials' of the technical intervention impacted on energy use behaviours (or practices). 'Materials' which work in unison with 'conventions' (the ideas of a practice being correct and normal) and 'competences' (the skills and knowledge to make equipment work), thus allowing a practice to occur (Hand et al., 2005). In some cases 'competencies' and 'conventions' existed or were gained through Gentoo Group communication on the Technical Intervention or possibly the Informational Interventions delivered as part of the PhD research. These components were accompanied then by 'materials' the introduced technologies and practices were formed, or energy use behaviour changed to begin using the introduced technologies.

5.4.3 Habit Influences Energy Use Behaviour

As indicated by the 'Core Findings Matrix' (table 28) and 'key patterns identified' (table 29) this similar energy use behaviour pattern occurred six times within three template themes. This 'key pattern' refers to cases where habit or routine create inertia in energy use behaviours so that they continue in the same or similar ways, regardless of the technologies introduced as part of the informational interventions. It was the intention of the Retrofit Realty project that the introduced technologies are used effectively or even used at all. Therefore it is important to acknowledge tenant's habit's, as changes in behaviour may be required to utilise new technologies, or use them effectively, to maximise retrofit effectiveness, thus improving energy efficiency and reducing carbon emissions.

Habits of Controlling Central Heating

Those tenants who did not change energy use behaviour to actively programme their central heating controls to come on at timed intervals, prefer to switch the off manually using a switch on the boiler itself. This does not allow heating to be activated automatically or by using the thermostatic controls and hot water is often switched off also with the same switch, only the pilot light of the boiler remains on. Tenants reported that they did this because they perceive it to save more energy than the heating being programmed to come on at timed intervals. Also many wished to override the pre-programming of the controls upon installation as they did

not understand how to change the settings. However, tenants also reported that they had always turned their heating and/or hot water on and off at the back boiler controls manually before the retrofit. It appears that this 'manual switching' energy use behaviour continued after the new central heating and combi-boiler was installed as part of the Technical Intervention. This suggests that this may be a habit or routine that has not changed regardless of the change in technology and introduction of separate heating controls, which are intended for use, yet still tenants use boiler switches to control heating just as they did with the previous boiler.

Programming the central heating controls to come on at timed intervals is considered an energy saving behaviour for the purpose of this research. However it should be noted that tenants who prefer to use 'manual switching' as (described above) may actually be more effective at saving energy than those who programme their central heating controls to come on at timed intervals. Tenants who 'manually switch', report that they only switch on the boiler when needed for example twice a day, for 40 minutes and only switch on the boiler briefly for hot water use before leaving it switched off. Tenants who programme their heating to come on at timed intervals must use four intervals so may use the heating for longer periods. However, it is not clear what the differences are in energy savings between 'manual switching' behaviour and the energy use behaviour of programming central heating controls to come on at timed intervals. It may be useful to explore this difference in future research, especially considering that many tenants in this social group spent more time at home through the day. Therefore they did not fit occupancy patterns which the programmable controls may have been targeted at, such as being out of the house through the day.

Habits of using the fire for space heating
It was Gentoo Group's intention that the retrofit of effective central heating would provide an alternative to using the fire as a method of space heating. The decision to install a type of fire was at the tenant's request, but Gentoo Group intended tenants to only use the electric fire for aesthetic purposes once installed. This was especially the case considering that the newly fitted electric fire was less efficient, more costly to run and is likely to contribute more carbon dioxide emissions due to being electrically powered. However, almost a half of all tenants continued to use the fire frequently as a source of space heating.

Prior to the interventions all tenants regularly used the gas fire as a source of heat. Tenants said this was due to the ineffective heating system, the house suffering

drafts and not retaining heat and the house taking a long time to heat. Thus tenants perceived that it would be costly and a waste of money to put the central heating on. Tenants therefore used the gas fire and tended to spend more time in the living room. This previous experience with the gas fire along with perceptions of wasted energy by using central heating may have created a habit of continuing to use the fire as a source of heat. This is regardless of the introduction of the central heating, having the means to control temperatures in different rooms with the radiator controls and the actual technology of the fire itself changing from gas to electricity. Tenants stated a preference for using a fire for space heating instead of the central heating, some regretted having the electric fire installed and wished they could have their gas fire re-installed. Tenants also reported routines that had developed prior to the Technical Intervention, which were continued after the technologies were changed or introduced as part of the retrofit. In these cases habits may lead to increased energy use, fuel cost and carbon emissions, because the technology has changed (to become less efficient, costly to run and indirectly emitting more carbon dioxide), but their behaviour has not changed. If the habit of using the fire was broken and tenants had instead used the central heating along with radiator controls to direct heat to only rooms where it was required, this would be likely to use less energy, reduce costs and reduce carbon emissions.

Habits for Bathing

Even though showers were introduced as part of the Technical Intervention some tenants continued to have baths instead of showers. These tenants reported that they always had baths because they liked the experience of having a bath. This may be simply a preference, but it may also be a habit or routine as a majority of tenants had always had a bath and no option of a shower, therefore they are used to the habit or routine of having a bath. It is also worth mentioning that the house and especially the bathroom were reported to be cold places before the retrofit and some said this was still the case after the Technical Intervention, due to an extractor fan and in some cases drafts from window sills. Tenants said that they would only bathe quickly in the shower because it was cold in comparison with the bath. Therefore it could be possible that tenants' habit of continuing to use the bath instead of using the shower may be maintained because the thermal comfort of the room has not changed significantly, and thus they continue with the same energy use behaviour of having a bath for reasons of comfort (also see 5.4.7).

Discussion in Relation to the Literature

The literature supports the finding that tenant's habits can influence energy use behaviour, where tenants continued behaviour prevents energy use behaviour change to begin using introduced technology, or use it effectively.

Tenants may not be consciously aware of behaviours or changes in behaviours. A number of tenants expressed that their behaviours had not changed as a result of the technical or informational interventions, even though they had reported significant behaviour changes between the baseline and follow up interviews. Implicit attitudes (which tenants are not aware of) can often explain more variance in behaviour than explicit attitudes (which tenants are aware of and communicate), which highlights that behaviour is frequently driven by unconscious processes, rather than deliberation (Maio et al., 2007). When an action is repeated several times to an individual's satisfaction, deliberation over the action is reduced and it becomes more automatic; it becomes a habitual action and is automatically triggered in particular circumstances without mediating a goal. In this case using conventional communication approaches to change behaviour will have minimal impact because habits undermine attention to information regarding other possible courses of action (Verplanken et al., 1997).

This goes against the rational choice model (discussed earlier), which argues that conservation based decisions can be influenced if consumers are provided with information relating to financial and performance advantages of alternative choices, enabling them to act accordingly. This is based on the assumption that: the foundations for human behaviour are based in self-interest, and; rational behaviour is the result of cognitive deliberation. Within the rational choice model, consumers require access to sufficient information in order to make informed choices about all the available options. However, Jackson (2005) notes that the rational choice model fails to acknowledge that an individual's ability to take deliberative actions is limited by the way that individual responds to affective or emotional influences. Cognitive deliberation is often completely bypassed because individuals use a variety of mental 'short-cuts' - habits, routines, cues, heuristics – which reduce the amount of cognitive processing needed. Thus a degree of routine enters our behaviour, making it much more difficult to change and undermines a key assumption of the rational choice model (Jackson, 2005). Habits then, seem unlikely to change, through the provision of information as outlined in the rational choice model, which is often used as guide for policy makers.

Verplanken and Wood (2006) argue that instead, habits need to be disrupted either by individuals making specific plans to carry out alternative actions or by using (or creating) changes in the environment in which individuals act, in order to force individuals to reconsider their behaviour options. In particular, using conventional communication approaches to change behaviour will have minimal impact because habits undermine attention to information regarding other possible courses of action (Verplanken et al., 1997). Instead, habits need to be disrupted either by individuals making specific plans to carry out alternative actions or by using (or creating) changes in the environment in which individuals act, in order to force individuals to reconsider their behaviour options (Verplanken and Wood, 2006). For example, travel habits are broken when people relocate or change employer; hence provision of information about public transport just after people have moved house is much more likely to encourage a change in travel mode, compared to providing this information under stable behavioural contexts (Bamberg, 2006; Verplanken et al., 2008).

In the context of a retrofit situation in social housing, the same changes in the fabric of the home and energy-related technologies provide scope for destabilising behavioural contexts and breaking habits where appropriate (i.e. where energy consumption can be reduced by braking habits). With the introduction of technological interventions fostered by a timely communication programme, there is also more potential for a change in energy use behaviours to use technologies effectively to save energy and engage in other energy saving behaviours.

Furthermore, pre-existing beliefs and views (i.e. attitudes) have been shown to bias perceptions and guide behaviour: people are more attentive to, and accepting of, attitude-consistent information and tend to ignore or reject dissonant information (Nickerson, 1998). This characteristic of attitudes should be acknowledged in communication approaches providing information on energy efficient behaviour. This is because tenants have stronger attitudes towards saving energy to save money rather than for environmental concerns, yet many Informational Intervention use the core rationale of environmental protection to encourage attitude and behaviour change.

It is worth noting that the Government's 'Nudge' approach could be utilised to disrupt habits. The current deployment of 'Nudge' is focused on encouraging the consumption of energy efficiency measures by making them financially attractive (for

example through Green Deal). However, there may be scope to use 'Nudge' through technology design and implementation to encourage a change in behaviour which coincides with its installation. Well designed and implemented technology could be used to 'Nudge' behaviour to effectively utilise it or encourage it to be used in a particular way.

5.4.4 External circumstances influence behaviour

As indicated by the 'Core Findings Matrix' (table 28) and the 'key patterns identified' (table 29) this similar energy use behaviour pattern occurred five times within four template themes. This 'key pattern' refers to cases where an external circumstance not directly related to the retrofit project or energy use behaviour themes impacts on energy use behaviours. Energy use behaviours may change due to other changing circumstances in tenants' lives and this may or may not contribute to the goals of the retrofit project to improve energy efficiency and reduce carbon emissions.

Closing curtains at night to keep heat in

A marginal number of tenants changed energy use behaviour to stop closing curtains at night to keep heat in. Tenants reported that this was because they had taken the curtains down to allow works to be completed, but then due to decorative preferences had not (yet), put curtains back up. As closing curtains is a form of draft reduction it could be argued that not having curtains (and thus not closing them) may slightly decrease the thermal retention and thermal comfort potential of the Technical Intervention, compared to also using curtains.

Filling the washing machine and keeping temperatures low

There was a slight change in this energy use behaviour from frequently filling the washing machine and keeping temperatures low, towards occasionally doing this. The most likely cause of changes in this behaviour is related to the introduction of infants into the household, within the 12 month period between baseline interviews and follow up interview. This change in household was noted by three tenants, who said that that they required higher temperatures to be used in the washing machine with washes without full loads due to more frequent cleaning requirements and more soiled clothing.

Awareness and use of energy efficient appliances

The retrofit in general created a context in which tenants invested in changes to appliances such as white goods and decorations. As tenants had been aware of the impending retrofit for some time they saved up money and waited until after the retrofit before making investments in these areas. Thus the retrofitting of homes may trigger the replacement of older and potentially less efficient appliances with newer models which may be more energy efficient and therefore assist the energy efficiency goals of the retrofit.

However, another external influence on the energy use behaviour of using white goods which are energy efficient appliances is the financial implications of the purchase of such appliances. Some tenants reported that they would always go for the cheaper appliance to stay within budget and found higher energy efficiency models more expensive. Therefore in the long-term these tenants may use more energy through the use of these 'cheaper' electrical appliances and overall pay more for running costs through fuel bills.

5.4.5 Quality of Technical Intervention influences behaviour

As indicated by the 'Core Findings Matrix' (table 28) and the 'key patterns identified' (table 29) this similar energy use behaviour pattern occurred four times within three template themes. This 'key pattern' refers to cases where the quality of the installation of the Technical Intervention influences energy use behaviour. As discussed in 5.4.2 the Technical Intervention can directly or indirectly have an impact on energy use behaviour. Therefore, if the way the technologies retrofitted as part of the technical intervention is not to the standard where it performs its function effectively, this will affect the degree of impact that it can have on tenant energy use behaviour, and thus tenant energy use behaviour itself.

Continued existence of drafts

Due to installation issues mainly related to the fitting of double glazed windows a number of tenants continued to experience drafts in the home after the technical intervention. As discussed in 5.2.3.1, draft reduction and improved thermal comfort due to the technical intervention changed energy use behaviours to cease draft controlling behaviours and wear warmer clothing occasionally. However, in cases where the technical intervention was not effective in reducing drafts and improving thermal comfort tenants continued draft controlling behaviours and behaviours to keep warm.

Location of thermostatic controls

There is a potential issue with the location of the central heating controls, in which the thermostat is contained. This location is subject to fluctuations in temperatures due to being located in the hallway, often in front of the double glazed door. Tenants rely on the temperature reading to guide the use of the central heating thus the his location can be a problem because the current temperature it is reporting (and target heating temperature) only relates to this part of the house. If a tenant sets the target temperature for the house, for example 19°C, the heating will actually heat the rest of the house to a higher temperature because the thermostat will take longer to reach its target temperature. Also conversely if temperatures were sometimes higher in the hallway due to sunlight on the controls, higher temperature settings would have to be entered into the thermostat to heat the house as the thermostat would switch off the heating before the remainder of the house reaches target temperature. These issues impact on the energy use behaviour of tenants relating to the use of thermostat controls because they need to adjust temperature settings to compensate for the location of the thermostat in a room with fluctuating temperatures.

5.4.6 Convenience of Technology Influences Behaviour

As indicated by the 'Core Findings Matrix' (table 28) and the 'key patterns identified' (table 28) this similar energy use behaviour pattern occurred four times within three template themes. This 'key pattern' describes the situation where energy use behaviours are influenced by tenants seeking convenience. This may lead to a change in energy use behaviour related to the Technical Intervention because it is 'easier' and/or 'quicker' to conduct this behaviour in comparison with the previous behaviour. With regard to energy use behaviours not associated with the Technical Intervention, inconvenience may also prevent energy use behaviour change to save energy or encourage energy use behaviour change to save energy because it is convenient.

Convenience increasing the frequency of hot water use

Before the technical intervention all tenants switched on the back boiler to warm up the hot water tank over a period of one to three hours planning water use activities around this time period, then used the hot water once it is heated. A majority of tenants only had the availability of baths for bathing. Tenants reported that they had baths approximately 2-4 times per week and sometimes shared bath water (with

children) or took turns with the same bath water with other household members. It is also possible that awareness of inefficiencies and energy costs may also have encouraged hot water saving behaviour. After the technical intervention, tenants would use the combi-boiler to provide hot water instantly, thus planning hot water activities was not required and the 'delay' or 'wait' as part of this behaviour is removed. Tenants then reported that access to hot water was much quicker, easier and more convenient. The frequency of bathing had increased, for example based on tenant statements the frequency of showers was 4-14 per household member per week. Thus it is possible that the increased convenience of the availability of instant hot water, may have increased energy use and water use or it may be similar to consumption before the technical intervention, even considering the efficiency improvements made.

Convenience preventing or encouraging energy use behaviour change

In the case of bathing, convenience may also have encouraged energy use behaviour change. Tenants reported that they used the shower instead of the bath after the interventions because it was much quicker and more convenient to use. Thus, the convenience of using the technology of the shower made it attractive to use the shower instead of the bath, and because showers use less energy to heat hot water than baths under normal use this change in behaviour due to convenience may have created energy savings.

With regard to boiling only the amount of water needed when boiling the kettle, there was a slight change in energy use behaviour where they had previously filled the kettle and not considered the amount needed. This was attributed to the informational interventions of written and verbal guidance on energy saving behaviours and the researcher information provided as part of the interviews. However it is also possible that those tenants who changed energy use behaviours to use the kettle more efficiently, did this not only because of the information to conduct this behaviour, but because they gained this knowledge *and* it was convenient (quicker) for them to do this. Indeed, tenants who already were using the kettle in an energy efficient way, said this was because they had learned about this behaviour from energy efficiency campaigns or parents (knowledge and skills) and found it quicker and easier (convenient) to boil the kettle with less water in it because they did not have to wait as long for the kettle to boil the smaller amount of water.

Tenants reported that convenience was preventing them from changing energy use behaviour to save energy by switching off all appliances completely when not in use (i.e. off standby). Tenants wanted to use the appliances (i.e. switch them on and use their functions or off when finished) quickly and/or easily and the nature of some appliances or their location limited the convenience of switching off appliances completely. For example, satellite boxes would take time to 'reboot' if switched off at the mains and as tenants found this inconvenient they left this appliance during day and night, along with other related entertainment appliances, such as Television, or video/DVD players (sharing the same multi way power sockets that plug in to the wall).

Tenants reported that the convenience of the location of power sockets also prevented changes in energy use behaviours to save energy, as tenants found it difficult and inconvenient to access certain sockets. Therefore, because power sockets were not easy to physically access or reach (e.g. low down, behind furniture or appliances), some tenants continued to leave appliances on standby for long periods when not in use.

Discussion in relation to the literature

The literature supports the finding that convenience may influence energy use behaviour to being using the technology introduced by the technical intervention, and that convenience links to our day to day practices, including energy use behaviour.

In the psychology literature related to consumption and food, convenience is described by Scholderer and Grunert (2005) as something that can be done with reduced effort related to dimensions of time, physical energy and mental energy. Individuals attempt to save time, physical energy and mental energy at different phases of a consumption process. This can also be related to energy use behaviour when tenants begin taking showers after the introduction of shower technology. Tenants associate the shower with being 'quicker' or 'easier' and thus opt for this form of washing behaviour.

From Practice Theory literature, in Hand et al's (2005) interpretation of showering with reference to the temporal organisation of daily life argues that 'speed' and 'convenience' are of defining importance and crucial in explaining both the general increase of showering and the decline of bathing. They argue that the key difference

between bathing and showering is that the latter is associated with speed, immediacy and convenience. The daily or weekly routine of (late) modern lifestyles is subject to temporal and sequential sequencing to fit practices around time pressures. This has resulted in temporal structures full of small episodes of attention, thus in this context the ability to 'slot in' a five-minute shower is appealing where a bath does not 'fit in' to the temporal structure (Hand et al., 2005). Showering as with other domestic devices has grown in popularity because they promise to help individuals cope with the temporal challenges they face in their day to day lives (Warde, 1999). While showers are not by definition, long or short, it is in relation to social conventions of time pressure, that people have come to understand showering as a technology of 'convenience' (Hand et al., 2005).

Also Practice Theory literature notes that the 'materials' or infrastructure providing constant availability of hot water and the concept of valuing of freshness may be related to the increased frequency at which people wash in recent times (Hand et al., 2005).The technologies introduced as part of the Technical Intervention provided this constant availability of hot water, where it was not immediately available prior to the retrofit. Similar to Hand et al's (2005) description, the infrastructure did provide constant availability of hot water, and shower technology, thus the convenience increased the frequency of hot water use and showering.

In relation to tenants' general energy use behaviour, a study by Edwards and Pocock (2011) notes that behaviour related to energy consumption is embedded in practices that are linked to the establishment and maintenance of effective household routine. In particular, energy consumption that promotes convenience in the operation of the household is likely to be practised, even if it somewhat contradicts attitudes to saving energy, or if it incurs costs. Conversely, the emphasis on household convenience means that people might energy in saving behaviour that might contradict their values. The study found that the priority given to convenience means that people will, for example: use inefficient sources of heating; allow their children to engage in high levels of energy and water consumption; not switch appliances off at the point when not in use. These findings concur with this PhD research findings, for example, energy use behaviour change to begin boiling only the amount of water required saved energy, but it also aligned with convenience needs in tenants lives by being 'quicker' to boil. Furthermore tenants expressed an attitude towards saving energy, but then reported that they did not switch off appliances completely because it was 'difficult' to reach the power sockets to switch

off or would take 'too long' for certain appliances to switch back on (e.g. satellite box).

5.4.7 Thermal comfort influences behaviour

As indicated by the 'Core Findings Matrix' (table 28) and the 'key patterns identified' (table 29) this similar energy use behaviour pattern occurred three times within three template themes. This 'key pattern' describes the situation the level of thermal comfort experienced by the tenant influences energy use behaviours. Generally the findings show that tenants do not wish to change energy use behaviours to save energy when it conflicts with needs or desires for thermal comfort. Also, improved levels of thermal comfort in the home, or access to technologies to improve thermal comfort (e.g. efficient central heating) may change energy use behaviours to behaviours which may save less energy (e.g. control drafts less, wear fewer items of clothing)..

For example, tenants reported thermal comfort reasons for preferring to take to take baths and not changing energy use behaviours to begin taking showers. These tenants found baths to be a warmer experience than showers and are willing to use and pay for more energy for this experience. Therefore, regardless of tenants in general expressing motivations to save energy, the energy use behaviour of taking baths instead of showers will not be changed by tenants who seek thermal comfort from bathing.

The thermal comfort of the home was improved by the technical intervention with the installation of technologies such as, more efficient central heating and double glazed windows. This provided less drafts and access to a more effective and efficient heating system. This change in environment due to technical intervention created a slight change in energy use behaviours, with some tenants ceasing to conduct draft controlling behaviour and wearing warmer clothing occasionally rather than frequently. Changing energy use behaviour to begin wearing warmer clothing occasionally rather than frequently could be considered a change in behaviour which saved less energy, because less heating would and energy use would be required should tenants have continued to frequently wear warmer clothing. It is possible that tenants used the central heating more because it was effective and tenants perceived it to be more efficient along with the other technologies, however this cannot be confirmed.

Discussion in Relation to the Literature

The literature supports the finding that thermal comfort may influence energy use behaviour related to the technical intervention. In the case of using the bath for bathing some tenants reported that they engaged in this energy use behaviour because it felt warmer than a shower. Some of these tenants said they were aware of the increased energy use and cost, but preferred baths. This indicates that some tenants perceive a loss in thermal comfort when taking showers instead of baths and thus did not change energy use behaviours for this reason.

Tenants may have used the introduced central heating technology to provide thermal comfort where thermal comfort was minimal before the technical intervention. This use of energy to take comfort after the energy efficiency is improved in a home is commonly called comfort 'takeback' (Milne and Boardman, 2000) and although it cannot be confirmed it is likely that comfort 'takeback' was conducted to some degree by tenants in this research. This may explain why people were expressing improved levels of thermal comfort, because drafts were reduced *and* central heating was effective and in use.

This change in behaviours which may have improved thermal comfort without using more energy (e.g. wearing more clothing) and thus could be considered a form of comfort 'takeback' (Milne and Boardman, 2000). Instead of continuing with energy use behaviours which attempt to minimise drafts and improve comfort through the use of clothing or blankets it appears that some tenants are now comfortable with certain temperatures, or they may be provided further comfort through heating use. This may potentially increase energy use and carbon emissions in comparison to before the Technical Intervention. Therefore, this particular change in behaviour may represent example of the technical intervention influencing behaviour to be less conserving of energy than before the technical intervention.

However, this increase in thermal comfort was welcomed by tenants with many reporting that their homes were very cold and draughty places to live in. Therefore losses in potential energy savings and carbon emission from the Technical Intervention, due to changes in energy use behaviour or comfort 'takeback' should be acknowledged, but nevertheless provide valuable health and wellbeing benefits to the tenants when homes are retrofitted effectively. Improved thermal comfort was welcomed by tenants who said they were happy and pleased with the improved

warmth in the home. Comfort 'takeback' should be acknowledged as an energy use behaviour change resulting from the technical intervention. As suggested by Milne and Boardman (2000) comfort 'takeback' can impact on the potential of energy efficiency measures to reduce carbon emissions and this may also have the case with the Retrofit Reality project. Although benefits to tenants from improved thermal comfort due to the retrofit are clearly worthwhile, it should be acknowledged that the energy efficiency improvements may be offset by increased energy use for comfort 'takeback' and carbon emissions may not be reduced as intended.

5.5   Conclusions

As this PhD took an inductive research approach, observations were made (data collection), then patterns were identified (data analysis), a tentative hypothesis was formulated to explore ('key patterns' identified) and conclusions were developed. Thus the findings of this research have been produced through an empirical process, however they may also raise more questions for further research, rather than to give answers and test theory. The following sections provide the key conclusions from the findings.

Impact of Technical Intervention on energy use behaviours

The technologies introduced as part of the technical intervention impact significantly on energy use behaviours (both directly and indirectly).The energy use behaviour template themes below show where significant energy use behaviour change occurred in a majority of tenants.

'Template themes' involving 'Direct Interaction' of behaviours with Technical Intervention:

- Using thermostatic control
  - 92% of tenants changed energy use behaviours to begin using the thermostatic controls, 69% of all tenants were using temperatures of 20°C or below.

- Using radiator controls
  - 81% of tenants changed energy use behaviours to begin using the radiator controls to some degree

- Fire use for space heating

- - 54% of tenants changed energy use behaviours to begin using only the central heating instead as a source of heat instead of the fire

- Hot water use (bathing)
  - - 59% of tenants changed energy use behaviours to change from mainly using a bath to bathe to mainly using a shower to bathe.

'Template themes' involving 'Indirect Interaction' of behaviours with Technical Intervention:

- Controlling drafts to maintain thermal comfort
  - - 53% of tenants changed energy use behaviours to cease controlling drafts

'Template themes' involving a 'Negligible Interaction' of behaviours (i.e. no interface) with the technologies installed as part of the technical intervention did not change significantly.

As shown above, even where energy use behaviours changed significantly to begin using the introduced technology, a number of tenants had not changed behaviours. This indicates that simply installing energy efficient technology in social housing does not necessarily yield the expected energy savings or carbon reduction because household occupants do not necessarily use the technology (or do not use it in an effective way).

Impact of Informational Intervention 2 on energy use behaviour

No significant impact on energy use behaviours could be found to be due to the informational intervention 2. Tenants reported that they were more aware about energy use and environmental issues, but variations in behaviour between the group that received written and verbal guidance (informational intervention 2) and the group that did not, were minimal. When there were significant differences between two groups this could be explained by other factors.

Factors influencing tenant energy use behaviour change

Access to knowledge and skills can prevent or allow retrofit technologies to be used effectively. Knowledge and skills can also prevent or allow energy saving behaviour which does not interact with the technology.

Tenants change their energy use behaviour as a result of technologies installed as part of the technical intervention. The change in environment or structure directly (behaviour involves using the technology) or indirectly (behaviour is influenced by the technologies properties) influences tenant energy use behaviour. This allows tenants to engage in behaviour where they previously were unable to do so due to the infrastructure available, therefore in some cases tenants begin using the technology.

Where tenants' habits or routines create inertia in energy use behaviours, their behaviours continue in the same or similar ways, regardless of the technologies introduced as part of the informational interventions. Thus introduced technologies are not used at all or not used effectively and potential energy saving and carbon reducing benefits may be negatively impacted.

External circumstances not directly related to the retrofit project or energy use behaviour themes may impact on energy use behaviours. Thus energy use behaviours change due to other changing circumstances in tenants' lives and this may or may not contribute to the goals of the retrofit project, i.e. to improve energy efficiency and reduce carbon emissions.

The quality of the installation of the Technical Intervention influences energy use behaviour. If the technology retrofitted as part of the technical intervention is not of a standard where it performs its function effectively, this may affect the impact that it can have on tenant energy use behaviour.

Convenience may lead to a change in energy use behaviour related to the Technical Intervention because it is 'easier' and/or 'quicker' to engage in this behaviour in comparison with the previous behaviour. With regard to energy use behaviours not associated with the Technical Intervention, convenience may also encourage energy use behaviour change or prevent energy use behaviour change and convenience can lead to behaviours which are conservative of energy or not conservative of energy.

Generally the findings show that tenants do not wish to change energy use behaviours to save energy when it conflicts with needs or desires for thermal comfort. Also, improved levels of thermal comfort in the home, or access to technologies to improve thermal comfort (e.g. efficient central heating) may change

energy use behaviours to behaviours which may save less energy (e.g. control drafts less, wear fewer items of clothing).

Barriers to retrofit effectiveness

The suggested barriers to retrofit effectiveness from the above can be considered to be:

- Limited access to knowledge and skills

- Habits preventing energy use behaviour change to begin using introduced technologies

- The quality of installation of the technical intervention not providing optimal functionality

- Convenience of the introduced technology potentially leading to increased energy use

- The need or desire for thermal comfort:
  - Preventing energy use behaviour change towards using introduced technologies, or;
  - Access to thermal comfort through technology potentially leading to increased energy use.

Changing technology or introducing technology into homes through an energy efficient retrofit can impact significantly on energy use behaviour, especially when energy use behaviour has a direct or indirect interaction with such technology.

This significant change in energy use behaviour can lead to effective use of technologies introduced as part of the retrofit. However this significant change in behaviour is most significantly demonstrated by tenants when they have access to knowledge and skills (or a minimum of change is required, e.g. technology is simple to understand/ use); their habits or routines do not prevent behaviour change; the quality of the retrofit technology allows functionality, and; the change in energy use behaviour does not conflict with tenants access to convenience or thermal comfort.

Tenants express attitudes towards saving energy mainly for financial reasons and report behaviours which are on the whole conserving of energy. These existing attitudes to saving energy and energy saving behaviours represent a platform for behaviour change towards an effective use of the introduced technologies and

developing other energy saving behaviours. However, behaviour-related barriers to the effectiveness of the retrofit will need to be addressed before tenants can maximise the energy saving and carbon reducing potential of their retrofitted homes.

6. Conclusions

This thesis evaluated a social housing retrofit project and its impact on tenant energy use behaviour. In doing so it aimed to:

- Evaluate the impacts of retrofit technologies on tenant behaviour related to energy-use

- Evaluate the impacts of written and verbal guidance on tenant behaviour related to energy-use

- Identify barriers to change in tenant behaviour related to energy-use which affect the effectiveness of retrofit technologies.

The thesis has found that social housing energy efficiency retrofit projects do have an impact on the energy use behaviour of tenants. No significant impacts of written and verbal advice on behaviours related to energy use could be identified in this research. The energy use behaviour of tenants can potentially act as a barrier to retrofit energy-saving effectiveness, and a number of such barriers have been identified. The following sections summarise the main findings, provide recommendations and discusses implications for policy, retrofit implementation and academic debates, and finally areas for potential future research.

6.1   Summary of Findings

6.1.1 Impacts of the Technical Intervention

There was a significant impact on behaviour related to energy use, specifically where a technology was introduced as part of the retrofit, and tenants' interacted with this technology directly or indirectly. The researcher identified three main categories of interaction with the technologies introduced as part of the technical intervention. These are outlined below along with associated 'energy-use behaviour themes' where the Technical Intervention had a significant impact on behaviours related to energy-use or did not have a significant impact on behaviours related to energy use.

Direct Interaction and Impact

Direct Interaction, the tenant interfaces with the technology directly in their behaviour (i.e. behaviour interacts with the technology). Behaviours related to energy use were significantly impacted by the Technical Intervention. When programming central heating controls, tenants changed behaviour to begin programming central heating controls. In using thermostatic controls, tenants changed behaviour to begin using thermostatic controls, keeping temperature settings at no more than 20°C. With regard to use of radiator controls, tenants changed behaviour to begin using radiator controls to provide different levels of heat in different rooms. In the case of fire use for space heating, tenants changed behaviour to cease using the fire for space heating and instead used the central heating. Finally with hot water use (bathing), tenants changed behaviour to begin using the shower for bathing.

These findings indicate that technology introduced as part of a retrofit does have an impact on energy use behaviour, especially when part of such energy use behaviour involves a technology which is altered or introduced as part of the retrofit. When technologies are introduced as part of a retrofit, behaviours do not always change to begin using the technologies effectively in order to yield the benefits that they provide, such as energy efficiency and carbon reduction. These cases could be considered detrimental to retrofit effectiveness as technologies often require appropriate operation to yield expected effectiveness. Put simply, if tenants don't change behaviour to use technologies or use them properly then the retrofit will be less effective in meeting its goals to improve energy efficiency and reduce carbon emissions.

Indirect Interaction and Impact

With *Indirect Interaction*, the tenant does not control the technology, but it's introduction can create a significant change in behaviour due to the influence of the technology on the tenants structural or environmental context (i.e. technology influences behaviour). Behaviours related to energy use were significantly impacted by the Technical Intervention because it changed the environment by improving thermal comfort and thus 'indirectly interacted' with tenants' behaviour. In relation to controlling drafts for thermal comfort and to keep warm, tenants' behaviour changed to cease controlling drafts as frequently. With regards to closing curtains at night to keep warm, tenants changed behaviour to stop closing curtains along with blinds. Also in the case of wearing warmer clothing rather than turning on the heating on or turning up the heating, tenants changed behaviour to stop wearing extra clothing to keep warm frequently, and began doing this occasionally.

These findings suggest that retrofit technologies can impact on behaviour even when there is no 'direct interaction' with the technology as part of the behaviour related to energy use. The improvement of thermal comfort for tenants is beneficial to tenants' health and wellbeing and therefore is a positive outcome of the Technical Intervention. However, this improved thermal comfort also seems to change behaviours related to energy use towards behaviours that are less conservative of energy. Thus it should be acknowledged that the installation of retrofit technologies increasing thermal comfort, may impact on occupant behaviour leading to further energy consumption and carbon emissions.

Negligible Interaction and Impact

With *Negligible Interaction and Impact*, the technologies of the technical intervention do not interact with behaviours related to energy use and there is a negligible change in behaviours. Energy use behaviours that were *not* significantly impacted by the technical intervention, within the following behaviour themes were:

- Carry out actions to cut down on gas use

- Carry out actions to cut down on electricity use

- Use energy saving light bulbs

- Switch off all appliances when not in use

- Boil only the amount of water needed when boiling the kettle

- Use full loads and low temperatures while using the washing machine

- Turn off any unnecessary lights

6.1.2 Impacts of Informational Intervention 2

No significant impact on energy use behaviours could be found to be due to informational intervention 2. Tenants reported that they were more aware about energy use and environmental issues, but there was minimal variation in behaviour between the groups that received written and verbal guidance (informational intervention 2) and the group that did not.

Tenants who had received Informational Intervention 2 reported more of a general change in energy use behaviour, however this was not verified by findings related to specific energy use behaviour themes.

6.1.3 Factors influencing tenant energy use behaviour change

In relation to the key patterns identified in the findings a number of factors were identified which influences energy use behaviour change. Access to knowledge and skills can prevent or allow retrofit technologies to be used effectively, or prevent or allow other energy saving behaviour (not interacting with the Technical Intervention). Tenants may change their energy use behaviour due to the installation of technologies as part of the technical intervention. This changes the environment or structure directly or indirectly (as discussed in 6.1.1) and this influences tenant energy use behaviour. Tenants' habits or routines may prevent change in energy use behaviours, their habits mean that behaviours existing prior to the retrofit continue post-retrofit, even though the technology and structure has changed. So introduced technologies may not be used (or used effectively), and technologies which have been changed (e.g. the gas fire is replaced with a less effective electric fire), may continue to be used even though they are likely to be less efficient and more costly.

External circumstances not directly related to the retrofit project or energy use behaviour themes may impact on energy use behaviours. Changing circumstances in tenants' lives influence energy use behaviour (such as the presence of children) and these behaviour changes may or may not contribute to the goals of the retrofit project, i.e. to improve energy efficiency and reduce carbon emissions. As the

technology can have an impact on energy use behaviour it is important to consider that the quality of the Technical Intervention and its installation can also have an influence on energy use behaviour. If the technology retrofitted as part of the technical intervention is not to a standard where it performs its function effectively, or is installed in a way which compromises its function, this may vary the impact that it can have on tenant energy use behaviour. Convenience can lead to a change in energy use behaviour related to the Technical Intervention because it is 'easier' and/or 'quicker' to engage in this behaviour, in comparison with the previous behaviour. With regard to energy use behaviours not associated with the Technical Intervention, convenience may also encourage energy use behaviour change or prevent energy use behaviour change can lead to behaviours which use more, or less energy.

6.1.4 Barriers to Retrofit Effectiveness

Considering the above factors influencing energy use behaviour, the following barriers to retrofit effectiveness have been identified.

Limited access to knowledge and skills

Access to knowledge and skills can prevent retrofit technologies from being used effectively. The change in environment or structure can directly (behaviour involves using the technology) or indirectly (behaviour is influenced by the technologies properties) influence tenant energy use behaviour. This allows tenants to engage in behaviour where they previously were unable to do so due to the infrastructure available, therefore in some cases tenants begin using the technology. However, if the tenants do not have access to knowledge and skills to utilise the technology it may not be used effectively, or at all and thus the energy saving and carbon dioxide reducing potential of the retrofit is diminished. This is perhaps the most important barrier to acknowledge as it was the most frequently occurring key pattern in the findings and because the retrofit technology is relied on as the main intervention to create energy savings, carbon reduction and tackle fuel poverty. If technology is not used effectively, this may result in minimal impact from the intervention or even lead to increases in energy use, carbon emissions and fuel poverty due to this gap in knowledge and skills.

Habits preventing behaviour change to utilise introduced technologies

Where tenants' habits or routines create inertia in energy use behaviours, their behaviours continue in the same or similar ways, regardless of the technologies introduced as part of the informational interventions. Thus introduced technologies are not used at all or not used effectively and potential energy saving, carbon dioxide reducing and fuel poverty tackling benefits may be negatively impacted. This is also an important barrier to acknowledge as habits may nullify the impact of efforts to provide knowledge and skills as habits are not determined by conscious deliberation based on information. However, in delivering new technologies there is a potential to make changes in the structure and environment which may disrupt habits and this has important implications for the design and delivery of future retrofit projects.

The quality of installation and function of the technical intervention

If the technology retrofitted as part of the technical intervention is not of a standard or not installed in a way in which it optional functionality, this may affect the impact that it can have on tenant energy use behaviour. This is important to acknowledge, but less critical than the other barriers mentioned here as improvements of standards in the installation of Technical Interventions via training is possible through various existing routes. However, one aspect which is worth consideration is the influence of technology design and its installation and how this may interact with occupant energy use behaviour.

Convenience of introduced technology potentially increasing energy use

Convenience may lead to a change in energy use behaviour related to the Technical Intervention because it is 'easier' and/or 'quicker' to engage in this behaviour in comparison with the previous behaviour. For example, access to instant hot water from the combi-boiler rather than the prior back boiler and water tank means that accessing hot water is more convenient, thus may be used more frequently. This means that the provision of technology may improve quality of life for tenants, but retrofit practitioners should be aware that this improvement in quality of life may lead to increased energy use. The factor of convenience is important to acknowledge as retrofit programmes may actually increase energy use in some cases and thus in real terms not achieve the energy saving, carbon dioxide and fuel poverty reduction goals which they aim to achieve.

The need or desire for thermal comfort

Generally the findings show that tenants do not wish to change energy use behaviours to save energy, when it conflicts with needs or desires for thermal comfort. This means that regardless of the technology involved or cost tenants may wish to access thermal comfort as a priority. This has important implications for retrofit programmes as the energy savings, carbon dioxide reduction and fuel poverty reduction may not be achieved if this factor is not further explored and addressed in a retrofit context. It is also worth noting that tenants may' takeback' comfort after Technical Interventions have been deployed because the system may be more efficient, so tenants will use the central heating more frequently (taking comfort), but pay similar fuel bill costs as before the retrofit. Also, improved levels of thermal comfort in the home, or access to technologies to improve thermal comfort (e.g. efficient central heating) may change energy use behaviours towards saving less energy (e.g. control drafts less, wear fewer items of clothing).

6.1.5 Understanding and Addressing Barriers to Retrofit Effectiveness

Several of the above barriers can be present at once, compounding each other in multiple ways depending on the particular tenant. It is worth while therefore to conduct further research to understand these barriers further and they relate in order to inform retrofit strategy. These barriers to retrofit effectiveness were confirmed by other findings in the research which showed that significant change in energy use behaviour can lead to effective use of technologies introduced as part of the retrofit, and this is the case when many of the barriers are not present. Change in behaviour to effectively use the retrofit technology is most significantly demonstrated by tenants when they have access to knowledge and skills (or a minimum of change is required, e.g. technology is simple to understand/ use); their habits or routines do not prevent behaviour change; the quality of the retrofit technology allows functionality, and; the change in energy use behaviour does not conflict with tenants access to convenience or thermal comfort.

Tenants express attitudes towards saving energy mainly for financial reasons and report behaviours which are on the whole conserving of energy. These existing attitudes to saving energy and energy saving behaviours represent a platform for behaviour change towards an effective use of the introduced technologies and developing other energy saving behaviours. However, behaviour-related barriers to the effectiveness of the retrofit will need to be further understood and addressed,

before tenants can maximise the energy saving and carbon reducing potential of retrofitted technology.

6.2   Recommendations

Policy makers and retrofit implementers should recognise the pivotal role that the behaviour of tenants and housing occupants in general, can have in determining retrofit effectiveness to save energy and reduce carbon emissions, and act on this knowledge.

In order to maximise the energy saving and carbon reducing potential of the UK's retrofit strategy, it is recommended that policy makers and implementers of retrofit programmes ensure that addressing occupant behaviour is a key part of strategy.

A potential approach in future UK retrofit strategy, in terms of addressing occupant behaviour could include the following components:

- *Developing more detailed understanding of occupant behaviour:* Research to improve understanding of occupant behaviour in the context of energy saving and carbon reduction potential. This would identify, a) impacts on behaviour related to energy-use arising due to the retrofit of technology that reduces energy saving potential or improves energy saving potential, and b) interventions for moderating impacts on behaviour related to energy-use that reduces energy saving potential, or encourage behaviour which increases energy saving potential.

- *Integrating communication and learning programmes with retrofit implementation:* Coinciding with the retrofit programme and potentially longer-term than the retrofit itself, a tailored communication programme or learning programme may reduce behaviour-related barriers to retrofit, such as limited access to knowledge and skills. In such a communication approach it would be important to consider the individual's motivations and to engage with an issue that conforms to an individual's motivations, attitudes and level of interest. For example, motivations and attitudes towards saving energy may be based on financial, rather than environmental reasons. The communication and learning programme would assist occupants by guiding them on effective use of technology or energy saving behaviours. These programmes could be reactive

and therefore attempt to respond to tenants' specific needs or behaviours to provide appropriate knowledge and skills. These programmes could also provide feedback from occupants on behaviour-related interaction with the retrofitted technology to inform strategy. This would contribute to other aspects of the strategy such as building understanding of occupant behaviour, or developing retrofit design standards incorporating occupant behaviour aspects, as noted below.

▪ *Developing retrofit design standards incorporating occupant behaviour aspects:* A standard of retrofit design and installation, which is developed over time by gaining feedback from research and practice could also include occupant behaviour aspects. Some behaviour-related barriers to retrofit may be mitigated by adapting the retrofit design or approach to take these factors into account.

▪ *Monitoring retrofit targets and goals:* Including consideration for occupant behaviour in the mechanisms for modelling and measuring the impact of UK retrofit programmes on domestic energy consumption and carbon emissions.

Further research could also be conducted on the above aspects and feasibility of the approaches before implementation (see 6.5 below). However, the structure suggested above would also be based on continual improvement, whereby the strategy is constantly improved during its development, based on processes that are found to be effective.

Considering the above research findings and recommendations it is important to consider the implications of this PhD research for policy and retrofit implementation.

6.3   Policy, Implementation and Reflection on the Literature

Retrofit programmes for installing energy efficient technologies in social housing, play an important part in the UK carbon reduction strategy. The findings of this thesis are therefore important for policy makers and retrofit implementers to consider. This research has provided an insight into the interaction between occupants and retrofit technologies in the context of a social housing retrofit. Although the interaction between occupant energy use behaviour and retrofit technologies is not completely understood, this thesis should nevertheless provide useful information on these aspects. Importantly, the thesis highlights that occupant

behaviour is worth considering in the ongoing 'retrofit debate' involving policy makers, retrofit practitioners, third sector organisations and academic institutions.

When compared to the existing attention given to physical retrofit measures, retrofit policy makers and programme implementers (such as social landlords), barely acknowledge the influence of occupant behaviour. Policy frameworks for behaviour change focus on encouraging or 'Nudging'' behaviour changes to purchase and retrofit energy efficient technologies, through financial incentives such as the Green Deal. However there is very limited focus on actual energy use behaviours or lifestyles in the context of buildings, retrofitting or in general. The evidence from this thesis could be utilised to encourage policy makers to pay more attention to the role of occupant behaviour in determining retrofit effectiveness and possibly incorporate the issue into retrofit strategy. With policy support, further research to understand the role of occupant behaviour in relation to energy efficient retrofits, and incorporation of occupant behaviour in the UK retrofit approaches and standards, future retrofit programmes may have more potential for saving energy and reducing carbon emissions from housing. Retrofit implementers such as social landlords can use the thesis findings to inform retrofit design and implementation. For example, the PhD research informs retrofit implementers on some of the potential barriers to retrofit effectiveness and thus enables them to target strategies to mitigate such barriers during implementation where possible.

Both within the academic and policy literature, there is limited evidence of how the energy use behaviours of social housing tenants are affected by the actual experience of a retrofit project. The recent literature has also highlighted how important occupant behaviour is in determining energy use. This research informs the literature by providing insights into social housing occupants' behaviour related to energy use, as they interact with technology introduced as part of an energy efficiency retrofit project.

It is important to stress that this PhD research does not attempt to 'combine' or even use a methodological approach from either disciplines of Psychological theory and Practice Theory. This is not an interdisciplinary research approach, but an evaluation of reported energy use behaviours using a qualitative approach and a generic template analysis of texts. Nevertheless, perspectives from both disciplines of psychological theory and practice theory were drawn upon when evaluating 'Key Patterns' of behaviour in the context of the literature. In this sense, this PhD

research is unique in its evaluation of behaviours related to energy use in a retrofit context, by drawing on the literatures of both disciplines to understand the phenomenon.

The theoretical perspectives from the psychology literature were overall, the most valuable for explaining the findings of this research. As much of the focus of this research is to evaluate the impact of the Technical Intervention (or retrofit technologies) on behaviour related to energy use and to identify behaviour-related barriers to retrofit energy saving effectiveness, emphasis is given to the impact of technologies installed on behaviour related to energy use. This emphasis on the impact of technology on agency and an individual's behaviour in the context of a retrofit means that the findings are framed in a way in that they are better explained by theoretical perspectives from the social psychology paradigm, rather than that of Practice Theory.

The entire research process began, out of needs to better understand 'behaviour' related to energy use and not 'practices' related to energy use. In this sense the research enquiry was naturally slanted towards gathering data and identifying findings related to 'behaviour' from the Psychology paradigm, rather than 'practices' from the Practice Theory paradigm. Nevertheless, Practice Theory was particularly useful for illuminating some key elements, such as the assertion that practices are not the result of a series of factors influencing our intention to 'behave', but the emergent outcome of combinations of elements (such as infrastructure and institutions) which already exist in the social world. Practice Theory also provides the contrasting perspective that human action is not necessarily determined by an individual's intention to act or an individual's lifestyle, but by an interaction between systems of provision and lifestyles. Interestingly, this interaction and resulting combination of elements can determine practices *and* be determined (or reshaped) by practices.

Practice Theory also brings forward useful perspectives of behaviour which draws the lens of inquiry away from the individual to encompass societal factors, such as the assertion that practices are not the result of a series of factors influencing our intention to 'behave', but the emergent outcome of combinations of elements (such as infrastructure and institutions) which already exist in the social world. In this sense Practice Theory is less applicable to understanding many of the specific behaviour-related finding of this research, however it may actually provide an

insightful approach should this perspective be applied more generally when looking at the concept of energy use behaviour and technology. Indeed, it would be interesting to see what findings and conclusions would arise should the research have been framed to answer a question regarding the impact of energy use *practices* in the context of social housing. Perhaps if this were the case the explanations for impacts on energy use behaviour would be rooted less in the individual reported actions in the home, but more on the impact of the 'systems of provision' on practices. Practice Theory also provides the contrasting perspective that human action is not necessarily determined by an individual's intention to act or an individual's lifestyle, but by an interaction between systems of provision and lifestyles. Interestingly, this interaction and resulting combination of elements can determine practices *and* be determined (or reshaped) by practices.

As noted earlier, this research has originality because it combines perspectives of the Psychology theory and Practice Theory. Though an inductive-based and explorative methodology it also provided a unique insight into occupant energy use behaviour by evaluating a 'live' project to retrofit energy efficient technology being implemented by Gentoo Group. It informs retrofit practitioners, and academic and policy debates on behaviour in the context social housing retrofit, by providing insight into the impacts of retrofit technology implementation on tenant behaviour related to energy use, and by identifying behaviour-related barriers to retrofit effectiveness.

6.4   Limitations

In order to investigate the behavioural aspects of tenant energy consumption, Gentoo Group part funded this PhD research project. The research design was constrained by the sponsor's organisational requirements which imposed a time-frame on the research which did not complement a traditional PhD research process. Due to Gentoo Group's management decisions the retrofit of technologies (technical intervention) was due to begin and this required almost immediate data collection.

This placed limitations on the research because there was not sufficient time to conduct a comprehensive literature review and plan the research in its entirety. A brief literature review was conducted which indicated key issues which assisted the research design process, however a more detailed literature review and more time

to plan the research may have allowed a more precisely targeted approach to data gathering. Due to the time limits a broader exploratory approach was utilised to gather data on a wide range of issues (such as, attitudes, knowledge, health and wellbeing and other environmental behaviours), but this data ultimately had to be put aside to maintain research focus and deadlines. If the data collection approach had been more specifically targeted perhaps the specific issues could be investigated in more detail and thus provide further insight. However, employing a broad exploratory approach did allow data to be captured where it would have otherwise been excluded from the analysis.

A key limitation of the research was that it was based on tenants' reported energy use behaviour which was possibly subject to biases in the way people report their views, such as social desirability. Tenants' responses may not have reflected their actual behaviours and they were reporting what they thought was 'the right thing to say'. It may even be the case that tenants were reporting on behaviour which they perceive that they engage in, but in reality this may not be the case.

To overcome this issue it may be possible to validate qualitative research with technical applications such as sensors, which can monitor the use of technologies or appliances without intruding on tenants' privacy. In addition, the availability of long – term high resolution energy consumption data may also help to verify if reported energy use behaviours relate to actual energy consumption data. Both these verification methods were not possible due to insufficient planning time for the former, and mainly due to problems obtaining long-term quality data for the latter.

This PhD research only evaluated tenants' behaviour related to energy use over a relatively short time period, following up with qualitative interviews approximately six months to a year after the retrofit. In this sense it only represents a 'snapshot' of tenants' behaviours before the retrofit and after. Tenants' behaviours may have further adjusted to the retrofit technologies after the follow up interviews, and energy use behaviours may subsequently be quite different. Thus the research is only representative of the particular time period over which it took place. If the research project had been longer it may have been possible to conduct a further follow up interview in order to monitor if the situation had changed. Nevertheless, the period over which the behaviour was evaluated for this PhD research is similar to periods used for the evaluation of building performance post retrofit, by models such as SAP.

6.5   Suggestions for Future Research

This PhD research identified potential barriers to retrofit effectiveness which require further research attention and related research topics are suggested below:

- Limited access to knowledge and skills and influence on behaviour change to effectively use retrofit technology, and behaviour change towards saving energy

- Habits and influence on behaviour change to effectively use retrofit technology, and behaviour change towards saving energy

- The quality of installation or functionality of the retrofit technology and its related impact on energy use behaviour and energy saving behaviour.

- Convenience of the retrofit technology and related impact on energy use behaviour and energy saving behaviour

- Thermal comfort provided by technology and related impact on energy use behaviour and energy saving behaviour.

There may also be other barriers to retrofit effectiveness or aspects of occupant energy use behaviour in the context of energy efficient retrofits that have yet to be revealed. This suggests that in general more research attention is required on occupant energy use behaviour in the context of energy efficient retrofits. This is especially relevant in the light of new policy mechanisms such as the Green Deal to be launched in October 2012. However, reflecting upon this PhD research a number of specific focus points of research are suggested below as future avenues to follow in order to improve understanding of energy use behaviour in the context of energy efficient retrofits to housing.

In the recommendations section (6.3) there is a suggestion of a potential approach to addressing occupant behaviour within UK retrofit strategy. These suggested components, based on the PhD research findings could be explored in several research projects. For example:

- A national field study of retrofit implementation, to identify: a) impacts on energy use behaviour arising due to the retrofit of technology that reduces energy saving potential or improves energy saving potential, and b) interventions for moderating impacts on energy use behaviour that reduce energy saving potential or encourage behaviour which increases energy saving potential.

- A desktop review of communication and learning programmes applied to technology interaction and energy saving behaviour, considering feasibility of integration with retrofit implementation.

- A desktop and/or field study exploring how occupant feedback can inform retrofit design and implementation standards.

A study evaluating the impacts of an energy efficient retrofit project could also utilise technology to monitor energy consumption and energy use behaviour patterns by employing sensors. For example, sensors may identify if a person is in a particular room or an appliance or light is on. This could be linked to qualitative data on reported energy use behaviour.

One aspect which arose in this PhD research is in relation to controlling central heating, and specifically concerning the use of programmable controls or manually switching on and off the boiler. This raised a potential research question: *Which types of energy use behaviours save the most energy and in what circumstances?* Programming the heating controls may for some households be the most energy efficient behaviour, however in other situations manually switching the boiler off and on for shorter intervals may save more energy. This like other specific energy use behaviour themes may be worth exploring in more detail to better tailor technology and energy use behaviour guidance to specific household or group needs.

References

Abrahamse, W. (2007) Energy conservation through behavioural change: examining the effectiveness of a tailor-made approach, *PhD thesis*, University of Groningen, The Netherlands.

Abrahamse, W., Steg, L., Vlek, Ch., & Rothengatter, J.A. (2005) A review of intervention studies aimed at household energy conservation, *Journal of Environmental Psychology*, 25, pp. 279-291.

Abrahamse, W., Steg, L., Vlek, Ch., & Rothengatter, J.A. (2007) The effect of tailored information, goal setting and tailored feedback on household energy use, energy-related behaviours and behavioural antecedents, *Journal of Environmental Psychology*, 27, pp. 265-276.

Ajzen, I. (1991) The theory of planned behaviour, *Organizational behavior and human decision processes*, 50, pp. 179-211.

Ajzen, I. & Fishbein, M. (1980) *Understanding attitudes and predicting social behavior.* Prentice-Hall, Englewood Cliffs, New Jersey.

Ajzen, I., & Madden, T. J. (1986) Prediction of goal directed behavior: Attitudes, intentions, and perceived behavioral control, *Journal of Experimental Social Psychology*, 22, pp. 453-474.

Alcock, P. (2010) *Big Society or civil society? A new policy environment for the third sector*, Third Sector Research Centre, Birmingham.

Anable, J. (2005) Complacent car addicts' or 'aspiring environmentalists'? Identifying travel behaviour segments using attitude theory, *Transport Policy*, 12(1), pp. 65-78.

APA (2009) *Psychology and global climate change: addressing a multi-faceted phenomenon and set of challenges*, a report by the American Psychological Association's Task Force on the Interface between Psychology and Global Climate Change, Available at:www.apa.org/releases/climate-change.pdf, Accessed on: 04/11/11.

Austin, P. & Sallabank, J. (eds.) (2011) *The Cambridge handbook of endangered languages*, Cambridge University Press, Cambridge.

Armitage, C.,& Conner, M. (1999) Distinguishing perceptions of control from self-efficacy: predicting consumption of a low-fat diet using the theory of planned behavior, *Journal of Applied Social Psychology,* 29, pp. 72-90.

Axelrod, L., & Lehman, D. (1993) Responding to environmental concerns: What factors guide individual action, *Journal of Environmental Psychology*, 13(2), pp. 149-159.

Bamberg, S. (2002) Effects of implementation intentions on the actual performance of new environmentally friendly behaviours – result of two field experiments, *Journal of Environmental Psychology*, 22(4), pp. 399-411.

Bamberg, S. (2006) Is a residential relocation a good opportunity to change people's travel behaviour? Results from a theory-driven intervention study, *Environment and Behavior*, 38, pp. 820-840.

Bamberg, S. & Schmidt, P. (2003) Incentives, morality, or habit? predicting students' car use for university routes with the models of Ajzen, Schwartz, and Triandis, *Environment and Behavior*, 35(2), pp. 264-285.

Bamberg S. & Möser, G. (2007) Twenty years after Hines, Hungerford, and Tomera: A new meta-analysis of psycho-social determinants of pro-environmental behaviour, *Journal of Environmental Psychology*, 27, pp. 14-25.

Bandura, A. (1982) Self-efficacy mechanism in human agency. *American Psychologist,* 37, pp. 122-147.

Bazeley, P. (2004) Issues in mixing qualitative and quantitative approaches to research. In, Buber, R., Gadner, J., & Richards, L., *Applying qualitative methods to marketing management research*, Palgrave Macmillan, UK.

Bergman, N., Hawkes, A., Brett, D.J.L., Baker, P., Barton, J., Blanchard, R., Brandon, N.P., Infield, D., Jardine, C., Kelly, N., Leach, M., Matian, M., Peacock, A. D., Staffel, I., Sudtharalingam, S. & Woodman, B. (2009) UK micro-generation. Part I: policy and behavioural aspects, *Proceedings of the Institution of Civil Engineering: Energy*, 162, pp. 23–36.

Bhaskar, R. (1989*) Reclaiming reality*, Verso, London.

Billig, M. (1999) Commodity fetishism and repression: Reflections on marxfreud and the psychology of consumer capitalism, *Theory and Psychology*, 9(3), pp. 313-329.

Blake, J. (1999) Overcoming the 'Value-Action Gap' in Environmental Policy: tensions between national policy and local experience, *Local Environment*, 4(3), pp. 257-278.

Blaxter, L., Hughes, C., & Tight, M. (2006) *How to Research*, Third Edition, Open University Press, Buckingham.

Boardman, B. (2007a) *Home truths: A low-carbon strategy to reduce UK housing emissions by 80% by 2050*, Environmental Change Institute, University of Oxford.

Boardman, B. (2007b) Examining the carbon agenda via the 40% house scenario, *Building Research and Information*, 35(4), pp. 363-378.

Bord, R.J., O'Connor, R.E., Fischer, A. (2000) In what sense does the public need to understand global climate change? *Public understanding of science*, 9, pp. 205-218.

Bourdieu, P. (1977) *Outline of a Theory of Practice*, Cambridge University Press, Cambridge.

Bourdieu P. (1984) *Distinction: A Social Critique of the Judgement of Taste*, Routledge, London.

Bowden, D. (2011) Goodbye nanny state, hello nudge, *The Free Society*, 26 January 2011, Available at:
http://www.thefreesociety.org/Articles/Comment/goodbye-new-labours-nanny-state-hello-lib-cons-nudge, Accessed on: 29/10/11.

Brandon, G. & Lewis, A. (1999) Reducing household energy consumption: a qualitative and quantitative field study, *Journal of Environmental Psychology*, 19, pp. 75-85.

Brannick, T. & Coghlan, D. (2007) Reflexivity in management and business research: what do we mean?, *The Irish Journal of Management*, 27(2), pp. 143-160.

Brayton, J. (1997) *What makes feminist research feminist? The structure of feminist research within in social sciences*, University of Brunswick, Available at:
http://www.unb.ca/PAR-L/win/feminmethod.htm, Accessed on: 21/12/11.

BRE (2008) *Domestic energy fact file 2008*, Building Research Establishment, Bracknell.

BRE (2008) *Carbon dioxide emissions savings from the Warm Front programme*, Building Research Establishment, Bracknell.

BRE (2009) *The Government's standard assessment procedure for energy rating of dwellings, 2005 edition, revision 3*, Building and Research Establishment, Bracknell.

Burgess, R. G. (1984*) In the field: An introduction to field research*, Routledge, London.

Burns, R (2000) *Introduction to research methods*, Sage Publications, London.

Cabinet Office (2010) *Building big society*, Cabinet Office website, Available at: http://www.cabinetoffice.gov.uk/sites/default/files/resources/building-big-society_0.pdf, Accessed on 06/10/2011.

Cabinet Office (2011) *Behaviour change and energy use*, Cabinet Office Behavioural Insights Team, London.

Camco (2011) *Green deal potential in social housing*, Report prepared on behalf of the National Housing Federation.

Candib, L. (1995) *Medicine and the family: A feminist perspective*, Basic Books: New York.

Cherry, N. (2000) *Action research: A pathway to action, knowledge and learning*, RMIT Publishing, Melbourne.

Climate Change Act (2008) HM Government, Office of Public sector Information, London.

Coffey, A. (1999) *The Ethnographic Self*, Sage Publications, London.

Cohen, D. A., Scribner R. A., &Farley, T. A. (2000) A structural model of health behavior: A pragmatic approach to explain and influence health behaviors at the population level, *Preventative Medicine*, 30(2), pp. 146-54.

Cole, R.J., Robinson, J., Brown, Z. & O'Shea, M. (2008) Recontextualizing the notion of comfort, *Building Research and Information*,36(4), pp. 323-336.

Cole, R. J. (2010) Green buildings and their occupants: a measure of success, *Building Research and Information*, 38(5), pp. 589-592.

Crabtree, B.F. & Miller, W.L. (1999) Using codes and code manuals: a template organizing style of interpretation. In, Crabtree, B.F. and Miller, W.L. (eds.) *Doing Qualitative Research*, Second Edition, Sage Publications, Thousand Oaks, California.

Crotty, M. (2003) *The Foundations of Social Research*, Sage Publications, London.

Darby, S. & White, R. (2005) *Thermal Comfort: Background document C for the 40% House Report*, Environmental Change Institute, University of Oxford, Available at:
http://www.eci.ox.ac.uk/research/energy/downloads/40house/background_doc_c.pdf
Accessed on: 17/12/11.

Darby, S. (2006) *The effectiveness of feedback on energy consumption: a review for DEFRA of the literature on metering, billing and direct displays*, Environmental Change Institute, University of Oxford.

Darnton, A. (2008) *GSR behaviour change knowledge review. Practical Guide: An overview of behaviour change models and their uses.* Report for Government Social Research Unit, London, Centre for Sustainable Development, University of Westminster.

Darnton, A, Verplanken, B, White, P and Whitmarsh, L (2011) *Habits, routines and sustainable lifestyles: summary report,* AD Research & Analysis for the Department for Environment, Food and Rural Affairs, London.

DCLG (2006a) *Review of sustainability of existing buildings: The energy efficiency of dwellings – initial analysis*, Department for Communities and Local Government, London.

DCLG (2006b) *A Decent Home: Definition and guidance for implementation*, June 2006 – update, Department for Communities and Local Government, London.

DCLG (2010) *Communities and Local Government carbon reduction delivery plan,* Department for Communities and Local Government, London.

DECC (2009a) *The UK low carbon transition plan: National strategy for climate and energy*, Department of Energy and Climate Change.

DECC (2009b) *Technical analysis of new measures in CERT, EXCERT-031*, Department of Energy and Climate Change, Available at: http://www.decc.gov.uk/assets/decc/162_20090309123432_e_@@_techanalysismeasurescert.pdf, Accessed on: 23/12/11.

DECC (2009c) *UK Fuel Poverty Strategy: 7th Annual Progress Report 2009*, Department of Energy and Climate Change.

DECC (2010a) *Chris Huhne's speech to LSE: Green growth; The transition to a sustainable economy*, 02/11/10, Department of Energy and Climate Change, Available at:
http://www.decc.gov.uk/en/content/cms/news/lse_chspeech/lse_chspeech.aspx, Accessed on: 21/11/11.

DECC (2010b) *The Green Deal – A summary of the Governments proposals*, Department of Energy and Climate Change.

DECC (2010c) *Warmer homes, greener homes; A strategy for household energy management*, Department of Energy and Climate Change.

DECC (2010d) *Estimated impacts of energy and climate change policies on energy prices and bills*, Department of Energy and Climate Change, Available at: http://www.decc.gov.uk/assets/decc/what%20we%20do/uk%20energy%20supply/236-impacts-energy-climate-change-policies.pdf, Accessed on: 21/11/11.

DECC (2011a) *Business plan 2011-2015*, Department of Energy and Climate Change.

DECC (2011b) *Feed-in Tariffs scheme: Summary of responses to the fast-track consultation and Government response*, Department of Energy and Climate Change, Available at: http://www.decc.gov.uk/assets/decc/Consultations/fits-review/fits-fast-track-government-response---final.pdf, Accessed on: 25/10/11.

DECC (2011c) *Consultation on proposals for the levels of banded support under the Renewables Obligation for the period 2013-17 and the Renewables Obligation Order 2012*, Department of Energy and Climate Change, Available at: http://www.decc.gov.uk/assets/decc/11/consultation/ro-banding/3235-consultation-ro-banding.pdf, Accessed on: 25/10/11.

DECC (2011d) *Renewable Heat Incentive (RHI) scheme: RHI update 7 October 2011*, Department of Energy and Climate Change, Available at:http://www.decc.gov.uk/en/content/cms/meeting_energy/Renewable_ener/incentive/incentive.aspx, Accessed on: 21/11/11.

DECC (2011e) *Renewable Heat Incentive*, Department of Energy and Climate Change, Available at: http://www.decc.gov.uk/assets/decc/What%20we%20do/UK%20energy%20supply/Energy%20mix/Renewable%20energy/policy/renewableheat/1387-renewable-heat-incentive.pdf, Accessed on: 25/10/11.

DECC (2011f) *Renewable Heat Incentive: frequently asked questions*, Department of Energy and Climate Change, Available at: http://www.decc.gov.uk/assets/decc/consultations/rhi/1_20100329163438_e_@@_rhifaqs.pdf, Accessed on: 25/10/11.

DECC (2011g) *Community Energy Saving Programme (CESP)*, Department of Energy and Climate Change, Available at: http://www.decc.gov.uk/en/content/cms/funding/funding_ops/cesp/cesp.aspx, Accessed on: 25/10/11, Department of Energy and Climate Change.

DECC (2011h) *Paving the way for a Green Deal – Extending the Carbon Emissions Reduction Target Supplier Obligation to December 2012*, Department of Energy and Climate Change, Available at: http://www.decc.gov.uk/en/content/cms/consultations/cons_cert/cons_cert.aspx, Accessed on: 25/10/11.

DECC (2011i) *Getting help where it is needed: a new Energy Company Obligation*, Department of Energy and Climate Change, Available at: http://www.decc.gov.uk/assets/decc/what%20we%20do/supporting%20consumers/green_deal/1732-extra-help-where-it-is-needed-a-new-energy-compan.pdf, Accessed on: 21/11/11.

DECC (2011j) *Energy Act 2011*, Department of Energy and Climate Change, Available at: http://www.decc.gov.uk/en/content/cms/legislation/energy_act2011/energy_act2011.aspx, Accessed on: 25/10/11.

DECC (2011k) *The UK Fuel Poverty Strategy 2001: Government response to the consultation on amending reference to the Warm Front Scheme eligibility criteria*, Department of Energy and Climate Change, Available at: http://www.decc.gov.uk/assets/decc/Consultations/warm-front-eligibility/1441-govtresp-warm-front-eligibility.pdf, Accessed on: 25/10/11.

DECC and EST (2011) *Home energy Pay As You Save pilot review*, Department of Energy and Climate Change and the Energy Saving Trust, Available at: http://www.decc.gov.uk/assets/decc/11/meeting-energy-demand/microgeneration/2670-home-energy-pay-as-you-save-pilot-review.pdf, Accessed on: 21/12/11.

DEFRA (2007) *Report, questionnaire and data tables following Survey of Public Attitudes and Behaviours toward the Environment: 2007*, Department for Environment, Food and Rural Affairs, Available at: http://www.defra.gov.uk/statistics/files/pas2007report.pdf, Accessed on: 21/12/11.

DEFRA (2008) *A framework for pro-environmental behaviours*, Department for Environment, Food and Rural Affairs.

DEFRA (2009a) *Attitudes and behaviour towards the environment* .Department for Environment, Food and Rural Affairs.

DEFRA (2011) *Framework for sustainable lifestyles*, Department for Environment, Food and Rural Affairs.

Denzin N. & Lincoln Y. (eds.) (2000) *Handbook of qualitative research*, Sage Publications, London.

DETR (2000) *Climate Change: The UK programme; summary*, Department of the Environment, Transport and the Regions, HMSO, London.

Deutscher, I. (1973) *Why do they say one thing, do another?*, General Learning Press, Morristown, New Jersey.

Directgov (2011) *Heating and insulation improvements from the Warm Front Scheme*, Available at:
http://www.direct.gov.uk/en/Environmentandgreenerliving/Energyandwatersaving/Energygrants/DG_10018661, Accessed on: 26/10/11.

Dwyer, W.O., Leeming, F.C., Cobern, M.K., Porter, B.E., & Jackson, J.M. (1993) Critical review of behavioural interventions to preserve the environment: Research since 1980, *Environment and Behaviour, 25, pp.* 275-321.

Eagly, A. H. & Chaiken, S. (1993*) The Psychology of attitudes.* Harcourt Brace Jovanovich, Fort Worth.

Eagly, A. H., & Chaiken, S. (2007) The advantages of an inclusive definition of attitude, *Social Cognition*, 25(5), pp. 582-602.

Eastby-Smith, M., Thorpe, R. and Lowe, A. (2002) *Management research: An introduction*, Second Edition, Sage Publications, London.

Edwards, J. & Pocock, B. (2011) *Comfort, convenience and cost: The calculus of sustainable living at Lochiel Park*, Centre for Work + Life, University of South Australia, Available at:
http://www.unisa.edu.au/hawkeinstitute/cwl/documents/Lochiel-Park-report.pdf, Accessed on: 16/11/11.

Ehrlich, P.R. & Ehrlich, A.H. (1991) *Healing the planet,* Addison Wesley*,* New York.

Electricity Act (1989) HM Government, Available at:
http://www.legislation.gov.uk/ukpga/1989/29/contents, Accessed: 08/12/11.

Emmert, S., Vand De Lindt, M., & Luiten, H. (Eds). (2010) *BarEnergy: Barriers to changes in energy behaviour among end consumers and households*, Available at: http://www.barenergy.eu/uploads/media/Barenergy_FinalReport_screen.pdf, Accessed on: 21/10/11.

Energy Act (2008) HM Government, Available at: http://www.legislation.gov.uk/ukpga/2008/32/contents, Accessed: 08/12/11.

Energy Act (2011) HM Government, Available at: http://www.legislation.gov.uk/ukpga/2011/16/pdfs/ukpga_20110016_en.pdf, Accessed: 20/10/11.

Environmental Audit Committee (2011a) *Environmental Audit Committee - Sixth report: Budget 2011 and environmental taxes: Session 2010-12, Volume 1*, Environmental Audit Committee, Available at: http://www.publications.parliament.uk/pa/cm201012/cmselect/cmenvaud/878/878.pdf, Accessed on: 21/10/11.

Environmental Audit Comittee (2011b) *Green economy: Written evidence submitted by the Aldersgate Group*, Environmental Audit Committee, Session 2010-12, Available at: http://www.publications.parliament.uk/pa/cm201012/cmselect/cmenvaud/writev/green/m37.htm, Accessed on: 21/10/11.

EPSRC (2010) *Details of grant: Carbon, control and comfort: User-centred control systems for comfort, carbon saving and energy management*, Available at:http://gow.epsrc.ac.uk/ViewGrant.aspx?GrantRef=EP/G000395/1, Accessed on: 17/12/2011.

EST (2007) *Green Barometer: Measuring environmental attitude*, Energy Saving Trust. Available at: http://www.energysavingtrust.org.uk/content/download/21447/80032/file/Green%20Barometer%20three.pdf, Accessed On: 21/02/10.

EST (2008) *Energy Saving Trust Website*, Available at: http://www.energysavingtrust.org.uk/, Accessed on: 07/11/08

EST (2009) *Carbon Emissions Reduction Target funding: Briefing note*, Energy Saving Trust.

EST (2010a) *Sustainable refurbishment: Towards an 80% reduction in CO$_2$ emissions, water efficiency, waste reduction, and climate change adaptation*, Energy Saving Trust, London.

EST (2010b) *Energy Saving Trust attitude tracker*, Energy Saving Trust.

EST (2011) *Feed-In Tariffs scheme (FITs)*, Energy Saving Trust, Available at:http://www.energysavingtrust.org.uk/Generate-your-own-energy/Financial-incentives/Feed-In-Tariffs-scheme-FITs, Accessed on 21/10/11.

Ezzy, D. (2002) *Qualitative analysis: Practice and innovation*, Allen & Unwin, Crows Nest, Australia.

Fazio, R. H., & Zanna, M. P. (1981) Direct experience and attitude-behaviour consistency. In Berkowitz, L. (Ed.), *Advances in Experimental Social Psychology*, 14, pp.161-202, Academic Press, New York.

Fazio, R. H., & Roskos-Ewoldsen, D. R. (2005) Acting as we feel: When and how attitudes guide behaviour. In, Shavitt, S& Brock, T. C.(eds.), *Persuasion: Psychological insights and perspectives,* Second Edition*,* Sage Publications, London.

Flick, U. (2006) *An Introduction to qualitative research*, Third Edition, Sage Publications, London.

Foster, D., Lawson, S., Winn, J., Noble, H., White, D., (2011) Using Grounded Theory to inform the design of energy interventions for the workplace, In, *Digital Engagement 2011*, November 15th-17th, Newcastle upon Tyne, UK.

Foucault, M. (1977) *Discipline and punish: The birth of the prison*, First American Edition, Pantheon Books, New York.

Gardner, G. & Stern, P. (2002) *Environmental problems and human behaviour*, Second Edition, Pearson Custom Publishing, Boston.

Gardner, B. & Abraham, C. (2008) Psychological correlates of car use: A meta-analysis, *Transportation Research Part F: Traffic Psychology and Behaviour*, 11(4), pp. 300-311.

Gas Act (1986) HM Government, Available at:
http://www.legislation.gov.uk/ukpga/1986/44, Accessed on: 08/12/2011.

Gatersleben, B. & Vlek, C. (1998) Household consumption, quality of life and environmental impacts: a psychological perspective and empirical study. In, Noorman, K.J. and Schoot-Uiterkamp, A.J.M. (Eds).*Green households? Domestic Consumers Environment and Sustainability*, Earthscan Publications, London.

Geller, E. S. (1989) Applied behaviour analysis and social marketing: An integration for environmental preservation, *Journal of Social Issues,* 45(1), pp. 17-36.

Gentoo Group (2008a) Footsteps: An environmental report by Gentoo, Gentoo Group Ltd, Accessed online:
http://assets.gentoogroup.com/assets/Downloads/Footsteps%20Environmental%20Report.pdf, Accessed on: 07/12/11.

Gentoo Group (2008b) Retrofit Reality Aims and Objectives, Gentoo Group Ltd, (Internal Document).

Gentoo Group (2009) Retrofit Reality: A Dissemination Report by Gentoo – part 2 of 3. Gentoo Group Ltd, Online Resource, Available at:
http://assets.gentoogroup.com/assets/Downloads/Docs/retrofit_2_rev.pdf, Accessed on: 21/12/11

Giddens, A. (1984) *The constitution of society – outline of the theory of structuration*, University of California Press, Berkeley and Los Angeles, California.

Gill, Z. M., Tierney, M. J., Pegg, I. M. & Allan N. (2010) Low-energy dwellings: the contribution of behaviours to actual performance, *Building Research and Information*, 38(5), pp. 491-508.

Glasman, L. R., & Albarracin, D. (2006) Forming attitudes that predict future behavior: A meta-analysis of the attitude-behavior relation, *Psychological Bulletin*, 132, pp. 778-822.

Glasser, B.G. and Strass, C. (1967) *The discovery of Grounded Theory,* Weidenfeld and Nicolson, London.

GlobeScan (2006) 2006 GlobeScan Corporate Social Responsibility monitor, *30-country poll finds worldwide consensus that Climate Change is a serious problem*, Available at:
http://www.worldpublicopinion.org/pipa/articles/btenvironmentra/187.php?nid=&id=&pnt=187, Accessed on: 30/01/09.

Goodmonson, C., & Glaudin, V. (1971) The relationship of commitment-free behavior and commitment behavior: A study of attitude toward organ transplantation, *Journal of Social Issues*, 27, pp. 171-183.

Gram-Hanssen, K. (2010) Standby consumption in households analysed with a Practice Theory approach, *Journal of Consumer Culture*, 5(2), pp. 131-153.

Gray, D. (2009) *Doing Research in the Real World*, Second Edition, Sage Publications, London.

Greenwald, A.G., & Banaji, M.R. (1995) Implicit social cognition: Attitudes, self-esteem, and stereotypes, *Psychological Review*, 102(1), pp. 4-27.

Guagnano, G, P Stern, and T Dietz (1995) Influences on attitude behavior relationships – a natural experiment with curbside recycling, *Environment and Behavior,* 27(5), pp. 699-718.

Halfpenny, P. and Reid, M. (2002) Research on the voluntary sector: an overview, *Policy and Politics*, 30(4), pp. 533-50.

Halpern, D., Bates, C., Beales, G., & Heathfield, A. (2004) *Personal responsibility and changing behaviour: The state of knowledge and its implications for public policy,* HMSO, London, Available at:
http://cdi.mecon.gov.ar/biblio/docelec/dp4105.pdf, Accessed on: 23/12/11.

Hand, M., Shove, E., & Southerton, D., (2005) Explaining Showering: a Discussion of the Material, Conventional, and Temporal Dimensions of Practice, *Sociological Research Online*, 10(2), Available at:
http://www.socresonline.org.uk/10/2/hand.html, Accessed on: 09/12/11.

Hargreaves, T. & Nye, M (2009) Exploring the social dynamics of pro-environmental behaviour change: A comparative study of intervention processes at home and work, *Journal of Industrial Ecology*, 14(1) pp.137-149.

Heijs, W. (2009) Residential energy use: habitual behaviour and possible interventions, *First European Conference on Energy Efficiency and Behaviour*, October, 18-20, 2009, Maastricht.

Hertwich, E.G. (2005) Consumption and the rebound effect: an industrial ecology perspective, *Journal of Industrial Ecology*, 9, pp. 85-98.

Housing Corporation (2008) *Housing Corporation in Fit for the Future: The Green Homes Retrofit Manual Technical Supplement.*

HM Government (2006) *Climate Change: The UK programme*, HMSO, London.

HM Government (2010)*Shaping our Future*, Office of Public Sector Information, London.

Huberman, A.M. & Miles, M. B. (1998) Data management and analysis methods: Methods of collecting and analyzing empirical materials. In, Denzin, N.K. & Lincoln, Y.S. (eds.), *Collecting and Interpreting Qualitative Materials,* pp. 179-207, Sage Publications, Thousand Oaks, California.

ISO 7730:2005, *Ergonomics of the thermal environment -- Analytical determination and interpretation of thermal comfort using calculation of the PMV and PPD indices and local thermal comfort criteria*, International Standards Organization, Geneva, Switzerland.

Jackson, K. (2003) Blending technology and methodology: A shift toward creative instruction of qualitative methods with NVivo, *Qualitative Research Journal*,3, (special issue), pp. 96-110.

Jackson, T. (2005) *Motivating sustainable consumption: A review of evidence on consumer behaviour and behavioural change*, Sustainable Development Research Network, Guildford.

Janda, K.B. (2009) Buildings don't use energy, people do. In, Demers, C.M.H. & Potvin, A. (Eds) *Proceedings of the 26th International Conference on Passive and Low Energy Architecture (PLEA)*, University of Laval Press, Quebec City, pp. 9-14.

Kaiser, F.G. Wolfing S., Fuhrer, U. (1999) Environmental attitude and ecological behaviour. *Journal of Environmental Psychology*, 19, pp. 1-19.

Kelley, S., & Mirer, T. W. (1974) The simple act of voting, *American Political Science Review,* 68, pp. 572–591.

King, N. (2004) Using templates in the thematic analysis of text. In, Cassell, C., & Symon, G., *Essential guide to qualitative methods in organizational research*, Sage Publications, Thousand Oaks, California.

Kok, R., Falkena, H.J., Benders, R., Moll, H.C., Noorman, K.J. (2003) Household metabolisim in European countries and cities: comparing and evaluating the results of the cities Fredrikstad (Norway), Groningen (The Netherlands), Guilford (UK), and Stockholm (Sweden), *Integration Report of WP2 (Toolsust Deliverable No.9), Groningen, The Netherlands: IVEM*, University of Groningen, Available at:http://www.toolsust.org/documents/D-9%20European%20report.pdf, Accessed on: 30/01/09.

Kollmuss, A., & Agyeman, J. (2002) Mind the gap: Why do people act environmentally and what are the barriers to pro-environmental behaviour. *Environmental Education Research*, 8(3), pp. 239-260.

Kraus, S. J. (1995) Attitudes and the prediction of behaviour: A meta-analysis of the empirical literature, *Personality & Social Psychology Bulletin*, 21(1), pp. 58-75.

Krosnick, J. A., & Petty, R. E. (1995) Attitude strength: an overview. In, Petty, R. E. & Krosnick, J. A. (eds.), *Attitude strength: Antecedents and consequences,* Laurence Erlbaum Associates, Mahwah, New Jersey.

Krosnick, J. A., & Smith, W. A. (1994) Attitude strength. In, Ramachandran, V. S. (Ed.),*Encyclopedia of human behavior*, Academic Press, San Diego, California.

Kuijer, L. & de Jong, A. (2011) Exploring practices of thermal comfort for sustainable design, *ACM CHI Conference on Human Factors in Computing Systems*, May, 7-12, Vancouver, Canada.

Kussen, C., & Yule, F. (2008) "I'm not in the habit of recycling": The role of habitual behaviour in the disposal of household waste, *Environment and Behavior*, 40(5), pp. 683-702.

Lather, P. (1988) Feminist perspective on empowering research methodologies, *Women's Studies International Forum*, 11(6), pp. 569-581.

LCEA Behaviour Change Retrofit Group (2011) *The missing quarter: Integrating behaviour change In low carbon housing retrofit*, Low Carbon Economic Area Behaviour Change Retrofit Group, Available at: http://www.svha.co.uk/downloads/svha_downloads/behaviour%20change%20report. pdf, Accessed on: 25/10/11.

Leiblich, A. (1998) *Narrative research: Reading, analysis and interpretation*, Sage Publications, Thousand Oaks, California.

Leaman, A., Stevenson, F., & Bordass, B., (2010) Building evaluation: practice and principles, *Building Research and Information*, 38(5), pp. 564-577.

Lindenberg, S., Steg, L. (2007) Normative, gain and hedonic goal-frames guiding environmental behaviour, *Journal of Social Issues*, 63(1), pp. 117-137.

Lord, C.G., & Lepper, M.R. (1999) Attitude representation theory, *Advances in Experimental Social Psychology*, 31, pp. 265-343.

Lorenzoni, I., Nicholson-Cole, S. & Whitmarsh, L. (2007) Barriers perceived to engaging with climate change among the UK public and their policy implications, *Global Environmental Change: Human and Policy Dimensions*, 17(3-4), pp. 445-459.

Luyben, P.D. (1982) Prompting thermostat setting behaviour: public response to a presidential appeal for conservation, *Environment and Behaviour*, 14(1), pp. 113-128.

MacMillan, K. (2005) More than just coding? Evaluating CAQDAS in a discourse analysis of news texts. *Forum Qualitative Sozialforschung / Forum: Qualitative Social Research*, 6(3), Art. 25, Available at: http://nbn-resolving.de/urn:nbn:de:0114-fqs0503257, Accessed on: 21/12/11.

Maio, G. R., & Olson, J. M. (eds.). (2000) *Why we Evaluate: Functions of attitudes*, Lawrence Erlbaum Associates Publishers, Mahwah, New Jersey.

Maio, G. R., Olson, J. M., Allen, L., &Bernard, M. M. (2001) Addressing discrepancies between values and behaviour: The motivating effect of reasons, *Journal of Experimental Social Psychology*, 37, pp. 104-117.

Maio, G. R., Verplanken, B., Manstead, A. S. R., Stroebe, W., Abraham, C., Sheeran, P., & Conner, M. (2007) Social psychological factors in lifestyle change and their relevance to policy, *Journal of Social Issues and Policy Review*, 1, pp. 99-137.

Mauthner, N. S. & Doucet, A. (2003) Reflexive accounts and accounts of reflexivity in qualitative data analysis, *Sociology*, 37(3), pp 413-431.

Mays, N. (1995) *Qualitative research design: An interactive approach*, Sage Publications, Thousand Oaks, California.

McKenzie-Mohr, D. (2000) Fostering Sustainable Behaviour through Community-Based Social Marketing, *American Psychologist*, 55(5), pp. 531-537.

McMeekin, A. & Southerton, D. (2007) *Innovation and final consumption: social practices, instituted modes of provision and intermediation*, Discussion Paper 79, presented at University of Hamburg, January 2007.

Midden, C., Kaiser, F., McCalley, T. (2007) Technology's four roles in understanding individuals' conservation of natural resources, *Journal of Social Issues*, 63(1), pp. 155-174.

Miles, M. B. & Huberman, A. M. (1994) *Qualitative data analysis*, Second Edition, Sage Publications, Thousand Oaks, California.

Ministerial Third Sector Task Force on Climate Change (2009) *Terms of Reference*, Available at: http://www.ncvo-vol.org.uk/climatechange-taskforce, Accessed on: 19/04/10.

Milne, G. & Boardman, B. (2000) Making cold homes warmer: the effect of energy efficiency improvements in low-income homes, a report to the EAGA Charitable Trust. *Energy Policy,* 28(6-7), pp. 411-424.

Morley, J. & Hazas, M. (2011) The significance of difference: Understanding variation in household energy consumption, European Council For an Energy Efficient Economy (eceee) 2011 Summer Study, *Energy efficiency first: The foundation of a low-carbon society: conference proceedings*, June, 6-11, Belambra Presqu'lle de Giens, France.

Murphy, E., Dingwall, R., Greatbatch, D., Parker, S., & Watson, P. (1998) Qualitative research methods in health technology assessment: A review of the literature, *Health Technology Assessment*, 2(16), Available at: http://www.hta.ac.uk/execsumm/summ216.htm, Accessed on: 25/11/11.

National Audit Office (2010) *The Decent Homes Programme*, Report by the Comptroller and Auditor General, HC 212, Session 2009-2010, National Audit Office.

National Statistics (2011) Annual report on Fuel Poverty statistics 2011, National Statistics.

NEA (2011) UK Fuel Poverty monitor 2011, National Energy Action.

NEA& JRF (2011) *Time to reconsider UK energy and fuel poverty policies*, National Energy Action and the Joseph Rowntree Foundation, Available at: http://www.nea.org.uk/assets/Uploads/NEA-JRF-Viewpoint.pdf, Accessed: 25/11/11.

NHF (2011) *Green Deal Working Group report*, National Housing Federation.

Nickerson, R. S. (1998) Confirmation bias: A ubiquitous phenomenon in many guises, *Review of General Psychology*, 2(2), pp. 175-220.

Nye, M., Whitmarsh, L. & Foxon, T. (2010) Socio-psychological perspectives on the active roles of domestic actors in transition to a lower carbon electricity economy, *Environment & Planning A*, 42(3), pp. 697-714.

Ofgem (2011a) *Ofgem's Report on the Community Energy Saving Programme (CESP) 2009-2012, to 31 December 2010*, Ofgem, London.

Ofgem (2011b) *A review of the third year of the Carbon Emissions Reduction Target (CERT)*, Ofgem, London.

Ofgem (2011c) *Carbon Emissions Reduction Target Update, Issue 13, September 2011*, Ofgem, London.

Palmer, J., & Cooper, I., (2011) *Great Britain's housing energy fact file 2011*, Prepared under contract to DECC by Cambridge Architectural Research, Cambridge Econometrics and Eclipse, Cambridge.

Petty, R.E. & Cacioppo, J.T. (1986) *The Elaboration Likelihood Model of persuasion*, Academic Press, New York.

Poortinga, W., & Pidgeon, N. (2003) *Public perceptions of risk, science and Governance: Main findings of a British survey of five risk cases*, University of East Anglia and MORI, Norwich.

Poortinga, W., Steg, L.,& Vlek, C. (2002) Environmental risk concern and preferences for energy-saving measures, *Environment and Behaviour,* 34(4), pp. 455-478.

Poortinga, W., Steg, L., Vlek, C., & Wiersma, G. (2003) Household preferences for energy-saving measures. A Conjoint Analysis. *Journal of Economic Psychology*, *24*, pp. 49-64.

Pope, C., Ziebland, S., & Mays, N. (2000) Qualitative research in health care: Analysing qualitative data, *British Medical Journal*, 320(7227), pp. 114-116.

POST (2005) Household Energy Efficiency, Postnote, Number 249, October 2005, Parliamentary Office of Science and Technology. Available at: http://www.parliament.uk/documents/post/postpn249.pdf, Accessed on 19/10/11.

Potter, J. & Wetherell, M. (1994) Analyzing discourse. In, A. Bryman and B. Burgess (Eds), *Analyzing Qualitative Data,* Routledge, London.

Pred, A. (1981) Social reproduction and the time-geography of everyday life, *Geografiska Annaler*, Series B, Human Geography, 63(1), pp. 5-22.

Reckwitz, A. (2002) Toward a Theory of Social Practices: A Development in Culturalist Theorizing, *European Journal of Social Theory*,5(2), pp. 243-263.

Reinders, A., Vringer, K., &Blok, K. (2003) The direct and indirect energy requirement of households in the European Union, *Energy Policy*, 31, pp. 139-153.

RIBA (2011a) *Climate Change Toolkit 02: Carbon Literacy Briefing*, Available at:http://www.architecture.com/Files/RIBAHoldings/PolicyAndInternationalRelations/Policy/Environment/2Carbon_Lit_Briefing.pdf, Accessed on: 20/10/11.

RIBA (2011b) *Climate Change Toolkit 03: Principles of Low Carbon Design and Refurbishment*, Available at:
http://www.architecture.com/Files/RIBAHoldings/PolicyAndInternationalRelations/Policy/Environment/2Principles_LC_Design_Refurb.pdf, Accessed on: 20/10/11.

Ross, L. (1977) The intuitive psychologist and his shortcomings: Distortions in the attribution process, *Advances in Experimental Social Psychology*, 10, pp. 173–220.

Robertson, J. (2002) Reflexivity redux: A pithy polemic on "Positionality", *Anthropological Quarterly*, 75(4), pp. 785-792.

Ryan, L. & Golden, A. (2006) "Tick the Box Please": a reflexive approach to doing quantitative social research, *Sociology*, 40(6), pp. 1191-2000.

Salzman, P. (2002) On reflexivity, *American Anthropologist*, 104(3), pp. 805-813.

Science and Technology Select Committee (2011) *Behaviour Change*, House of Lords Science and Technology Select Committee: 2nd Report of Session 2010-2012. The Stationary Office, London.

Schatzki, T. (2001) Introduction: Practice Theory. In, Schatzki, T., Knorr Cetina, K. & von Savigny, E. (eds.)*The practice turn in contemporary theory*, Routledge, London.

Scholderer, J., Grunert, K. G. (2005) Consumers, food and convenience: The long way from resource constraints to actual consumption patterns, *Journal of Economic Psychology*, 26(1), pp. 105-128.

Schönfelder, W. (2011) CAQDAS and Qualitative Syllogism Logic—NVivo 8 and MAXQDA 10 Compared, *Forum Qualitative Sozialforschung / Forum: Qualitative Social Research,* 12(1), Art. 21, Available at: http://www.qualitative-research.net/index.php/fqs/article/view/1514/3134, Accessed on: 22/12/11.

Schuman, H., & Johnson, M. P. (1976) Attitudes and behavior, *Annual Review of Sociology*, 2, pp. 161–207.

Schwartz-Cowan, R. (1983) *More work for mother: the ironies of household technology from the open hearth to the microwave*, Basic Books, New York.

Schwarz, N. (2007) Attitude Construction Evaluation in Context. *Social Cognition*, 25(5), pp. 638-656.

Scott, J., & Marshall, G. (eds.) (2005) *A Dictionary of Sociology*, Oxford University Press, Oxford.

Seale, C. (2010) Using computers to analyse qualitative data. In, Silverman, D. *Doing qualitative research: A practical handbook,* pp. 251-267, Sage Publications, London.

Seligman, C., Kriss, M., Darley, J. M., Fazio, R. H., Becker, L. J., & Pryor, J. B. (1979) Predicting summer energy consumption from home-owners' attitudes, *Journal of Applied Social Psychology*, 9, pp. 70–90.

Shank, G. (2002) *Qualitative research: A personal skills approach*, Prentice Hall, New Jersey.

Shove, E. (2003) *Comfort, cleanliness and convenience – the social organisation of normality*, Routledge, London.

Shove, E. (2009a) *Habits and their creatures*, short paper, Available at: http://www.lancs.ac.uk/staff/shove/transitionsinpractice/tip.htm, Accessed on: 06/12/11.

Shove, E. (2009b) The ABC of energy efficiency and behaviour, Keynote presentation, *First European Conference on Energy Efficiency and Behaviour*, October, 18-20, 2009, Maastricht, the Netherlands.

Shove, E, (2009c) *Beyond the ABC of sustainable behaviour*, presentation, University of Wageningen, April, 16, 2009, Wageningen, the Netherlands.

Shove, E. (2010) Beyond the ABC: climate change policy and theories of social change, *Environmental Planning A*, 42, pp. 1273-1285.

Shove, E (2011) On the difference between chalk and cheese – a response to Whitmarsh et al's comments on "Beyond the ABC: climate change policy and theories of social change*", Environment and Planning A*, 43(2), pp. 262-264.

Shove, E. & Southerton, D. (2000) Defrosting the freezer: From novelty to convenience*, Journal of Material Culture,* 5(3), pp. 301-319.

Silverman, D. (2010) *Doing qualitative research*, Third Edition, Sage Publications, London.

Smith, E.R., & DeCoster, J., (2000) Dual-process models in social and cognitive psychology: Conceptual integration and links to underlying memory systems. *Personality and Social Psychology Review*, 4, pp. 108-131.

Smith, E. R., & Makie, D. M. (2007) *Social Psychology*, Third Edition. Psychology Press, Hove, UK.

Smith, W., Pett, J. (2005) *Energy efficiency refurbishment programmes help, but are the end-users doing their bit?,* Association for the Conservation of Energy, London.

Southerton, D. (2003) "Squeezing Time": allocating practices, co-ordinating networks and scheduling society, *Time & Society*, 12(1), pp. 5-25.

Southerton, D. Shove, E. & Warde, A. (2001) Harried and hurried: time shortage and the coordination of everyday life, *CRIC Discussion Paper No. 47*, The University of Manchester & UMIST.

Southerton, D., & Tomlinson, M. (2003) "Pressed for Time" –the differential impacts of a "time squeeze", *CRIC Discussion Paper No 60,* The University of Manchester & UMIST.

Spaaragen, G., & Van Vliet, B. (2000) Lifestyle, consumption and the environment: the ecological modernisation of domestic consumption, *Society and Natural Resources*, 9, pp. 50-76.

Spence, A. (2005) Using implicit tasks in attitude research: A review and a guide, *Social Psychology Review*, 7, pp. 2-17.

Spence, A., Venables, D., Pidgeon, N., Poortinga, W. & Demski, C. (2010) *Public perceptions of Climate Change and energy futures in Britain: Summary findings of a survey conducted from January to March 2010*, Understanding Risk Working Paper 10-01, Cardiff University, Cardiff.

Staats, H. (2003) Understanding pro-environmental attitudes and behaviour: an analysis and review of research based on the theory of planned behavior. In, Bonnes, M, Lee, T., & Bonaiuto, M. (eds.), *Psychological Theories for Environmental Issues*, Ashgate Publishing, Aldershot.

Stake, R. (2010) *Qualitative research: Studying how things work*, The Guilford Press, New York.

Steg, L. (2008) Promoting household energy conservation, *Energy Policy*, 36(12),pp. 4449-4453.

Steg, L. & Vlek, C. (2009) Encouraging pro-environmental behaviour: An integrative review and research agenda, *Journal of Environmental Psychology*, 29, pp. 309-317.

Stenberg, J., Thuvander, L., & Femenias, P. (2009) Linking social and environmental aspects: a multidimensional evaluation of refurbishment projects, *Local Environment*, 14(6), pp. 541-556.

Stern, P, Dietz, T., Abel, T. Guagnano, G. & Kalof, L. (1999) A value-belief norm theory of support for social movements: the case of environmental concern, *Human Ecology Review,* 6, pp. 81-97.

Stern, P., Dietz, T., & Kalof, L. (1993) Value orientations, gender, and environmental concern, *Environment and Behaviour*, 25(3), pp. 322-348.

Stern, P. & Kirkpatrick, E. (1977) Energy behaviour: conservation without coercion, *Environment*, 10, pp. 10-15.

Stern, P. (2000) Toward a coherent theory of environmentally significant behaviour, *Journal of Social Issues*, 56(3), pp. 407-424.

Stevenson, F. & Leaman, A. (2010) Evaluating housing performance in relation to human behaviour: new challenges, *Building Research & Information*, 38(5), pp. 437-441.

Stevenson, F. & Rijal, H. B. (2010) Developing occupancy feedback from a prototype to improve housing production, *Building Research & Information*, 38(5), pp. 549-563.

Strauss, A. & Corbin, J. (1998) *Basics of qualitative research*, Second Edition, Sage Publications, Thousand Oaks, California.

Tenant Services Authority (2010) *Personal Communication with Carol Harrison*, Customer Services Advisor, TSA, (19th April 2010).

Thaler, R., & Sunstein, C. (2003) Liberal Paternalism Is not an oxymoron, *University of Chicago Law Review*, 70(4), pp.1159-1203.

Thaler, R., & Sunstein, C. (2008) *Nudge: Improving decisions about health, wealth, and happiness*, Yale University Press, Yale.

Thøgerson, J. (2007) Social marketing of alternative transportation modes. In, Gärling, T., & Steg, L. (eds.), *Threats to the quality of urban life from car traffic: Problems, causes and solutions*, Elsevier, Amsterdam.

Thøgerson, J., & Ölander, F. (2006) To what degree are environmentally beneficial choices reflective of general conservation stance? *Environment and Behavior*, 38(4), pp. 550-569.

Triandis, H. C. (1977) *Interpersonal behaviour*, Brooks/Cole, Monterey, California.

Trochim, W. (2006) *Induction and Deduction*, Available at: http://www.socialresearchmethods.net/kb/dedind.php, Accessed on: 21/12/11.

Utilities Act (2000) HM Government, Available at: http://www.legislation.gov.uk/ukpga/2000/27/contents, Accessed on: 08/12/11.

van Manen, M. (1990) *Researching lived experience: Human science for an action sensitive pedagogy*, State University of New York Press, Abany, New York.

van Oel, C. J., Bogerd, A., & de Haas, G. J. (2009) Occupant-owners preferences in decision making of low energy renovation concepts, *First European Conference on Energy Efficiency and Behaviour*, October, 18-20, 2009, Maastricht, the Netherlands.

Verplanken, B., Aarts, H., & van Knippenberg, A. (1997) Habit, information acquision, and the process of making travel mode choices, *European Journal of Social Psychology*, 27, pp. 539-560.

Veplanken, B., Aarts, H., van Knipperberg, A., & Moonen, A. (1998) Habit versus planned behaviour: a field experiment, *British Journal of Social Psychology*, 37, pp. 111-128.

Verplanken, B., & Holland, R. (2002) Motivated decision-making: Effects of activation and self-centrality of values on choices and behaviour, *Journal of Personality and Social Psychology*, 82, pp. 434-447.

Verplanken, B., & Wood, W. (2006) Interventions to break and create consumer habits*, Journal of Public Policy and Marketing*, 25, pp. 90-103.

Verplanken, B., Walker, I., Davis, A., & Jurasek, M. (2008) Context change and travel mode choice: Combining the habit discontinuity and self-activation hypotheses*, Journal of Environmental Psychology*, 28, pp. 121-127.

Vlek, C., Jager, W. & Steg, L. (1997) Modellen en strategieën voor gedragsverandering ter vermindering van collectieve risico's (Models and Strategies for Behaviour Change Aimed at Reducing Collective Risks), *Nederlands Tijdschrift voor de Psychologie (Dutch Journal of Psychology)*, 52, pp. 174-191.

Vlek, C., & Steg, L. (2007) Human behavior and environmental sustainability: Problems, driving forces and research topics, *Journal of Social Issues*, 63 (1), pp. 1-19.

Wall, R., Devine-Wright, P. & Mill G. (2004) *Organised Activity? A critical review of theoretical constructs used to explain environmentally-significant behavior*, Mimeo, De Montford University, Leicester.

Warde, A., Shove, E., & Southerton, D. (1998) Convenience, schedules and sustainability, *European Science Foundation Workshop on Consumption*, Everyday Life and Sustainability, 7–29 March, Lancaster University.

Warde, A. (1999) Convenience food: space and timing, *British Food Journal,* 101(7), pp. 518-27.

Warde, A. (2005) Consumption and Theories of Practice, *Journal of Consumer Culture,* 5(2), pp. 131-153.

Warm Front (2011) *Connecting with communities: The Warm Front Scheme Annual Report 2010/11*, Warm Front.

Weber, E. U. (1997) Perception and expectation of climate change: Precondition for economic and technological adaptation. In, Bazerman, M.H., Messick, D.M., Tenbrunsel, A.E. & Wade-Benzoni, K. A. (eds.) *Environment, and behaviour: The psychology of environmental valuation and degradation*, The New Lexington Press, San Francisco, California.

Weber, R. (2003) The reflexive researcher, *MIS Quarterly*, 27(4), pp. v-xiv.

Whitmarsh, L., & O'Neill, S. (2010) Green identity, green living? The role of pro-environmental self-identity in determining consistency across diverse pro-environmental behaviours, *Journal of Environmental Psychology*, 30(3), pp. 305-314.

Whitmarsh, L., O'Neill, S., Lorenzoni, I. (2011a) Climate change or social change? Debate within, amongst, and beyond disciplines, *Environment and Planning A,* 43(2), pp. 258-261.

Whitmarsh, L., Upham, P., Poortinga, W., McLachlan, C., Darnton, A., Devine-Wright, P., Demski, C., & Sherry-Brennan, F., (2011b) *Public Attitudes, Understanding, and Engagement in relations to Low-Carbon Energy: A selective review of academic and non-academic literatures*, Report for RCUK Energy Programme.

WHO (2007) *Housing, Energy and Thermal Comfort: A review of 10 countries within the WHO European Region*, World Health Organisation, Regional Office for Europe.

Wicker, A. W. (1969) Attitudes versus actions: the relationships of verbal and overt behavioural responses to attitude objects, *Journal of Social Issues*, 25, pp. 41-78.

Wicker, A. W. (1971) An examination of the "other variable" explanation of attitude–behavior inconsistency, *Journal of Personality and Social Psychology*, 19, pp. 18-30.

Williams, M. (2000) Interpretivism and generalisation, *Sociology*, 34(2), pp. 209-224.

Williams, M., & May, T. (1996) *Introduction to the Philosophy of Social Research*, Routledge, London.

Willig, C. (2001) *Introducing qualitative research in psychology: Adventures in theory and method,* Open University Press, Buckingham and Philadelphia.

Wiseman, J. P. (1978) The Research Web. In, Bynner J., & Stribley, K. M. (eds), Social research: Principles and procedures, Longman, London.

Wolf, D. L. (1996) Situating Feminist dilemmas in fieldwork. In, Wolf, D. L., (ed.), *Feminist Dilemmas in fieldwork*, Westview Press, Colorado.

Wood, W. (2000) Attitude change: Persuasion and social influence, *Annual Review of Psychology,* 51, pp. 539-570.

Wood, W., & Neal, D. T. (2007) A new look at habits and the habit-goal interface, *Psychological Review*, 114(4), pp. 843-863.

Zajonc, R. B. (1968) Attitudinal effects of Mere Exposure, *Journal of Personality and Social Psychology*, 9(2), pp. 1-27.

Zanna, M. P., & Fazio, R. H. (1982) The attitude–behavior relation: Moving toward a third generation of research. In, Zanna, M. P., Higgins, E. T.,& Herman C. P.(eds.), *Consistency in social behavior: The Ontario Symposium*, 2, pp. 283-301, (Vol. 2, pp. 283–301), Lawrence Erlbaum Associates Publishers, Mahwah, New Jersey.