Factors that affect the diffusion and impact of domestic 'green technology' and the role of 'place'

Alice Margaret Owen

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School of Geography

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The candidate confirms that the work submitted is her own, except where work which has formed part of jointly authored publications has been included. The contribution of the candidate and the other authors to this work has been explicitly indicated below. The candidate confirms that appropriate credit has been given within the thesis where reference has been made to the work of others.

The formation of a conceptual framework in Chapter 3, the exploration of the case in Section 4.1.5 and the cross-case analysis in Section 4.2.2 contain information published in the following two papers:

- Owen, A, Mitchell, G and Clarke, M, 'Not just any old place', Engineering Sustainability,Vol 164, March 2011, Issue ES1 pp 5-11
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Abstract

Consumption of non-renewable resources is unsustainable at the per capita levels currently found in the UK. This thesis aims to identify factors which affect the take-up and use of a range of domestic green technologies which, if successfully deployed, could reduce the resource consumption of UK households. The adoption and use of these technologies is examined through five case studies of area-based schemes where a local authority or a locally-based not-for-profit group has made a concerted effort to promote technologies which might reduce the impact of domestic resource consumption. Previous analyses of the adoption and impact of low carbon energy technologies in the home have focussed on technology or on users. Because of the scale of technological and behavioural change required to reduce carbon emissions from domestic energy consumption, and because area-based approaches are attractive to achieve change at scale, this research adds *place* to the list of influences to be considered.

Case study data was collected by interviewing scheme managers, technology advisers and installers, technology adopters and non-adopters. The data is organised around a conceptual framework which provides an analytical template drawing on innovation diffusion, environmental psychology and neighbourhood effects literature.

Cross-case analysis suggests that physical aspects of place and the technology's relative advantage dominate developing an intention to adopt, while the acquired aspects of place are critical in translating intention into adoption. However, place appears to play little role in the impact of technology after adoption. An important extension to existing theory revealed through the analysis is the role of the installer in shaping both the technology attributes that are important to adoption, and the (potential) user attitudes that are important to both adoption and use, together with the user capacity (perceived behavioural control) which shapes the use and therefore impact of domestic green technology.

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Chapter 1 Introduction and Rationale for Research

1.1 Background

Three observations motivated my initial enquiries and led to this research project and thesis. These observations arose from several years working in various professional roles supporting projects which intended to help people live more sustainable lives.

First, a project which was successful in one location could not be readily transplanted to another location and replicate that success. What might appear to be the same approach in project scale and objectives would play out differently in different locations, apparently because of 'place' factors: the people in that place and the physical and social landscape that those people inhabited. This general question, too broad to be a research question, "Why do things fly differently in different places?" is of great interest to practitioners in social policy and has led to the production of many typologies of place, seeking to identify the variables which determine what place-specific outcomes will be (Lupton et al., 2010). These variables might be differences between urban and rural areas accounted for by differences in infrastructure provision (Peattie, 2010), and there is some focus on cities in particular as sites of transition to more sustainable lifestyles (Hodson and Marvin, 2010). For example, mapping the installation of solar photovoltaic (PV) cells registered for the Feed-in Tariff (FiT) in the UK shows variations between local authority areas (DECC, 2012c). Analysis has been carried out to seek links with variables such as aspects of deprivation, existing levels of electricity and gas use, age of household or type and tenure of housing stock (DECC, 2012b). In Germany, there is also wide regional variation in the uptake of PV despite a consistent national financial incentive and that regional variation cannot be explained by geo-physical factors such as incident radiation (Dewald and Truffer, 2012). As well as spatial variations in levels of technology adoption, there are observable differences in the spatial variations of environmental pressures such as (for the UK) water availability (Environment Agency, 2008) or environmental quality including air pollution and water quality (Environment Agency, 2012).

Second, technology is often identified as a possible solution for a social or environmental problem, but a given piece of technological equipment rarely performs exactly as the designer had intended or specified. For example, energy efficiency measures may not reduce consumption as much as expected, due to some form of rebound effect (Sorrell, 2009), discussed further in Section 1.5.4 below. Context and user behaviours alter what technology does and therefore there are intended and unintended consequences from technology adoption. Post-occupancy surveys of buildings, even those intended to be sustainable buildings with low levels of resource use, do not always report the full positive impacts on resource use, noise and air quality which were intended, although other positive outcomes such as increased productivity or the image presented to visitors to the building may be noted (Baird, 2010).

Thirdly, pressures to live more sustainably seem to heap up on every side. All natural resources seem to be under pressure, and human quality of life is dependent on the health of those resource stocks (e.g. Seymour and Girardet, 1988). The scale of change demanded to achieve sustainability is huge. It is not enough to make minor adjustments to current lifestyles (Brown, 2008). However, when seeking (rapid) evolution rather than revolution, we need to start with current lifestyles and homes. A systemic approach to change appears the only approach fit for the scale of the challenge.

These three observations helped establish a field of enquiry. I am not claiming any novelty in the observation of these phenomena; rather I am interested in a more nuanced understanding of how effective responses to these observations can be developed. Reviewing the literature pertinent to these observations refined the broad agenda into more focussed research questions, which in turn supported a research philosophy, design and method. Before plunging into the research project, this chapter sets out the context for the project, followed by the boundaries defined to focus the research.

1.2 Structure of this thesis

This introductory chapter sets out the rationale for the research and defines its boundaries within what is an enormous sphere of interest. Chapter 2 reviews several areas of theory relevant to developing a conceptual framework for how households adopt and use green technology. This literature review includes strands of socio-technical systems, environmental psychology, innovation diffusion, practice theory and neighbourhood effects theory. The second part of the literature review in Chapter 2 synthesises and critically evaluates the findings of empirical studies that have collected data relevant to the adoption and use of domestic green technology in several different countries. On the basis of this review, Chapter 2 highlights particular gaps in current knowledge and proposes research questions that respond to these gaps. Chapter 3 establishes the research philosophy appropriate to answering the research questions proposed in Chapter 2 and develops the conceptual framework that underpins the research design. The details of the research design and method are then described. Chapter 4 presents the findings from analysing the case studies of area-based schemes intending to reduce the impact of resource consumption through deploying technology. The five area-based schemes are each described with summary data in the Sections of 4.1. Section 4.2 then draws together a cross-case analysis, looking for the patterns and differences identified in the case studies and returns to how the case study data respond to the research questions. Chapter 5 reflects on the case study analysis to suggest contributions to theoretical knowledge and contributions to practice which can be drawn from this research. The limitations of the research are also acknowledged and the implications of those limitations are discussed in Chapter 5. The final chapter, Chapter 6, draws together overall conclusions from the research and suggests further research that might strengthen and extend these findings. A series of appendices then contain information, much of which is provided to show how the results offered in Chapter 4 and discussed in Chapter 5 can be traced back to the original data.

1.3 Why is this research relevant and important?

1.3.1 Carbon emissions and resource consumption need to be reduced

In many countries, resource use per capita is increasing, closely coupled to economic growth (Jackson, 2009b). At the same time, the world's population is increasing, from 2.5 billion in 1950, to around 7 billion today, with forecasts ranging from 8 to 11 billion people by 2060 (UN, 2009). It seems inevitable that demand for resources will continue to escalate. But the stocks of many resources are not infinite, and in some cases available resources are declining (WWF et al., 2010). The same research indicates that, globally, we are consuming more resources than the planet can provide in a renewable manner, and that the trend is for global consumption to continue to rise. Allied to resource use is the production of waste. Reducing resource consumption also reduces waste, and therefore reduces the pressures on natural systems to absorb wastes (McDonough and Braungart, 2002). A rapid reduction in total resource demand is needed.

An important issue within the impacts of resource use is anthropogenic climate change. Use of non-renewable sources of energy leads to a change in the atmospheric concentration of carbon dioxide, which then alters climate through the 'greenhouse effect' (IPCC, 1990). A changing climate has many impacts on human well-being, including changing crop yields, water distribution, direct impacts on human health, decreasing infrastructure resilience to extreme weather events and increasing the vulnerability of low-lying settlements as sea levels rise (IPCC, 2007, p10, Figure SPM7). Such impacts mean that climate change is a high-profile political issue. Alongside climate change, energy security is an increasing concern for national governments, with improving energy efficiency viewed as one of the main actions needed to improve energy security (International Energy Agency, 2012). These two pressing issues mean that in practice, an interest in reducing carbon dominates both the published work on resource consumption and many people's thinking about resources. In the UK, policy goals focus on energy and related carbon emissions and the UK's statute includes a legal requirement for the government to reduce carbon emissions. The Secretary of State for Energy and Climate Change is accountable for whether or not the UK's emissions are 80% lower in 2050 than the 1990 baseline (Her Majesty's Government, 2008). Across Europe, national governments have committed to the "20:20:20" goals: a 20% cut in emissions of greenhouse gases; a 20% share of renewable energy in final energy; and a 20% cut in energy consumption through energy efficiency improvements, all by 2020 (European Commission, 2010).

Reducing resource use and the impact of resource use as part of 'sustainable development', rather than as part of 'development', cannot be achieved at the cost of social capital and well-being. In the UK, the national strategy for sustainable development has five principles and two overarching outcomes, one of which is "to live well within environmental limits" (Her Majesty's Government, 2005). The simplicity of this desired outcome belies a range of complex challenges. Challenges include recognising the "social logic" (Jackson, 2005) that drives individuals to consume in pursuit of well-being while data shows a disconnect, above a certain threshold, between increased well-being and increased consumption (Offer, 2006). There are also considerable problems in the distribution of both affluence and well-being, in spatial and in sociodemographic terms, leading to debates about the interplay between social and environmental justice (Lucas et al., 2004). As well as the intrinsic justice of distributing resources and their benefits more fairly between different populations and groups today, sustainable development also expects the distribution of resources between generations or 'intergenerational equity' (e.g. Dresner, 2002).

1.3.2 Technology change is one way to reduce resource consumption

If it is accepted that resource use per capita, and the impacts of that resource use, must be decreased, what are the potential means to achieve that end? A society's total resource impact or demand can be described by the I=PAT equation which appears in various forms (Chertow, 2001) and which developed from debates, primarily in the USA, about the root causes of environmental problems (Ehrlich and Holdren, 1971). The I=PAT equation suggests Impact (I) is the product of population (P), affluence (A) or level of consumption per capita, multiplied by a factor which represents the level of technology which that society can deploy to moderate its resource use (T). Thus, to reduce resource use the options include reducing population, reducing levels of affluence, or applying technological fixes to counter the growth trends in these two.

There are myriad difficulties in achieving global population reductions including a significant inertia in the current, upward, trends which means that it seems to be near impossible to reduce population in the timeframe that international carbon reduction targets and commitments require. Thus, in practice, population growth is usually accepted as a 'given'. Equally problematic is the acceptability of suggesting that a reduction in affluence should be the focus when globally many people live on less than $1 a day (The World Bank, 2012), although there may well be a case to consider the impact of reduced affluence in developed economies. Advocates for a move towards a steady state economy suggest measures of economic growth which include the quality of growth rather than simply its magnitude (Daly, 2008) and the reporting and development of measures which assess well-being (e.g. OECD, 2011) indicate that there are positive outcomes to be realised from transforming the idea of affluence to include well-being rather than being solely based on income.

While acknowledging the potential in tackling both 'P' and 'A', it is the final factor 'T', changing the impact of consumption through altering technology, that is the focus of this thesis. Technology solutions to tackle the negative impacts of unsustainable resource production also offer the potential benefits of the economic development in the design, manufacture, deployment and maintenance of low carbon and sustainable resource use technologies (Schreurs, 2012).

Changing the 'level' of technology, T in the I=PAT equation, might occur at the national or regional level through altering infrastructure, at the firm level through improving process efficiencies, or at the domestic level through changing appliances and equipment. In each case, technology is considered to improve the efficiencies of existing economic activity, rather than radically altering the nature of economic activity. This kind of efficiency is a 'factor four' approach, whereby economic activity increases at the same time as resource use decreases, mainly through technology efficiency (von Weizsacker et al., 1998). While absolute decoupling of resource use and economic growth is not being observed (Jackson, 2009b), many forecasters and modellers are convinced of the contribution that technology could play in reducing the impacts of resource use. Considering carbon emissions in isolation, economists developed a series of policy "wedges" that illustrated how technology might be deployed to achieve an 80% reduction in emissions. One path is that 27% of stabilisation in greenhouse gas emission growth could come from two "wedges" of energy efficiency and renewable energy generation (Pacala and Socolow, 2004). A substantial proportion of the benefits of both of these areas for action can be delivered through implementing novel technologies. At the more local scale, evaluation of area-based schemes in the UK supporting whole streets to reduce energy consumption identified the deployment of new technology as the critical factor to a scheme's success (Platt et al., 2011). However, it should be noted that technology is embedded in wider innovation systems shaped by a regulatory, institutional and cultural context. These factors, particularly the institutional factors, have been identified as important in accelerating the deployment of renewable energy technologies (Jacobsson and Johnson, 2000).

1.3.2.1 But don't focus solely on technology!

In using the I=PAT equation as a framing device and examining the impacts of implementing technology, I do not mean to suggest a 'techno-fix' approach where technology alone can solve the issues of resource use. Technology functions within a context, an issue explored further in Section 2.1.1 of the literature review considering socio-technical systems. The point is made very eloquently in buildings-related research that "buildings don't use energy, people do" (Janda, 2011), and the same applies to other resources. Rather, this research could be thought of as extending the trend of buildings performance research to move beyond the technical and instead use case studies to investigate the social and economic factors that affect the impact of technology in the domestic environment and that lock users into patterns of resource use (Schweber and Leiringer, 2012), as well as answering the call for research to "address structural or contextual factors that influence energy demand and research" (Summerfield and Lowe, 2012). I therefore extend 'social and economic factors' into geographic factors to incorporate further aspects of place.

Despite this cautionary note, technology does provide one vital element of a transition to a low carbon economy. The wider view of how technology-based transitions occur and literature on technological regime shifts, including a historic perspective and analysis of previous shifts in technology, is explored in Section 2.1.1.

1.3.3 A focus on the developed world

Resource consumption in the developed and developing worlds differ in two important respects: the levels of consumption and the drivers of consumption. Developed economies account for a much higher proportion of resource use than developing economies. A measure which illustrates this clearly is "ecological footprint" (Wackernagel and Rees, 1996), which translates all resource consumption associated with the lifestyle of an individual in a geographic location (usually a country) into a measure of the 'bioproductive area' of the planet required to support that lifestyle. Equal distribution of resources would mean each individual having an ecological footprint of 1.8 global hectares (the bioproductive area of the planet, divided by the total global population). The most recent assessment of the ecological footprint of lifestyles in different countries demonstrates that such a distribution is far from the case (WWF et al., 2010). Developed economies have a per capita ecological footprint much higher than developing economies. The same pattern can be seen with per capita carbon emissions (International Energy Agency, 2012). Thus the challenge of reducing resource consumption is most urgent in the developed world where this research focuses.

Equally, issues related to improving well-being are different in the developing and the developed world. In developing countries, the primary well-being issues are ones of physical health and economic well-being, as illustrated by the Millennium Development Goals (UNDP, 2010). Increasing affluence, or rather alleviating poverty, up to a threshold, does appear to support these goals. However, in developed countries, discussions of improving well-being give greater attention to issues of mental health, community and belonging, and the impacts of over-consumption, such as obesity. Thus, when considering how green technology can be applied in developed countries and economies, questions of how adopting green technology might contribute to aspects of sustainability beyond reduced resource use also need to be evaluated. These may not be economic benefits, which might actually be relatively small for individual households, but instead perceived benefits might be in terms of comfort, status, or congruence with pro-environmental values.

1.4 The domestic arena

UK homes accounted for 25% of UK emissions and 40% of energy use in 2009, with space and water heating consuming over three quarters of domestic energy used (DECC, 2011a). Considering carbon emissions, the Committee on Climate Change (CCC), the body charged with guiding the UK government's actions in meeting statutory emissions reductions, estimates that homes contribute 13% (85 $MtCO_2e$) of the UK's climate changing emissions, the fourth largest contribution after power generation, industry and transport. Reducing these emissions could be achieved by reducing energy consumption through the curtailment of energy use or through investments in energy efficiency in the home (Gardner and Stern, 2002). Domestic energy conservation technologies include those which reduce energy losses in the home, such as insulation, and those which improve the efficiency of energy use, such as energy efficient lighting and appliances. In some analyses, although not in general usage, "appliances" includes the devices used for space heating, or cooling, which account for between one quarter and one half of residential electricity use in a variety of developed countries – US, Canada, Australia, New Zealand and the UK as well as the EU27 in aggregate (Kelly, 2012). Emissions can also be reduced by decarbonising the electricity or heat supply. On the domestic scale this means installing renewable microgeneration technologies such as solar thermal systems, heat pumps or biomass boilers for heat, and solar photovoltaic cells, wind turbines and micro-hydro turbines for electricity. Ensuring that new buildings are energy efficient has been codified in England into building regulations, which set the standards for new building performance, but a major challenge still lies in retrofitting the existing building stock with low carbon energy technologies. Approximately 75-80% of the UK's 2050 building stock, which will need to meet UK carbon budget targets, already exists (SDC, 2006) and therefore retrofitting these properties will have a greater impact than incorporating the highest standards of resource efficiency into new buildings.

Modelling undertaken for the CCC suggests that up to 40 MtCO2e could be removed from domestic emissions by 2020 if energy efficiency measures and lifestyle changes are implemented. Approximately a further 60 MtCO2e reduction could be delivered through domestic renewable microgeneration, although this is more expensive (CCC, 2008). The CCC's realistic forecasts of what could be achieved by 2020 are 9-18 MtCO2e from energy efficiency and 10 MtCO2e from microgeneration. It has been recognised that reducing emissions in existing buildings requires a transdisciplinary approach but despite, or perhaps because of, this, reducing energy use through domestic energy efficiency measures is proving more challenging than expected, by building designers, at least (Lomas, 2009). Additionally, modelling of the potential to improve the energy use of existing buildings in the UK does not take account of the technology buying behaviours of households and the impact of those behaviours on technology adoption (Lee and Yao, 2013).

Another reason to limit the research scope to the household arises from theoretical analysis that suggests household behaviours and associated resource consumption is socially constrained, embedded within routines, habits and the normative practices of "everyday life" (Southerton et al., 2004). So examining "everyday life", or the domestic arena, provides a lens through which to examine resource use and possible reductions. Using "everyday life" as a focus also provides a link between the technology-based literature (explored in Section 2.1.2) and the environmental psychology-based literature (explored in Section 2.1.3) which are not routinely brought together, as the review that follows shows.

While the importance of domestic resource consumption has been noted and discussed for decades, in the UK, quantitative data which offers deep insights into the patterns of resource use is only just being collected and published for electricity (Owen, 2012) and water (Clarke et al., 2009, Hassell, 2012). These data are making descriptions of resource use much more robust, but still leave open the motivations and drivers of these patterns of resource use.

Examples include the decisions that are taken about the frequency and timing of running wet appliances, or the decisions over the location and size of lighting.

Implementing technologies in homes involves a different set of actors compared with implementing technologies in centralised power generation or in commerce and industry. For this reason, a focus on the domestic arena provides useful insights, although ones not necessarily transferable to the commercial or industrial arena.

1.4.1 Scale

Another pertinent area of debate is whether implementing technology at a large scale achieves system-wide benefits unavailable to individual domestic units: the "pro-scale" debate (Jonas, 2006, Hudson, 2007). If this is the case, then the impact of individual domestic technology adoption decisions would be affected by whether a number of other households had also adopted the technology in sufficient volume to make a difference. Microgeneration is a good example of green technology illustrating this point. While adopting microgeneration may bring a household direct benefits such as reduced costs or increased resilience, the household can only receive those benefits if there has been a co-evolution of the technology, the sector and the national or global structures required to support it, such as ensuring the ability of an electricity network to receive generated electricity from small, distributed sources. Domestic microgeneration of electricity only functions well if action at other scales is also undertaken (Rip, 1998).

Related to this is the eco-localisation discussion where it is asserted that individual and collective action, taken in a place-specific way, is essential to community and settlement resilience (Hopkins, 2008, Barles, 2010, North, 2010). Actions promoted by eco-localisation typically encompass reducing the geographic extent of resource cycles including energy, water and food. Eco-localisation overlaps with some aspects of ecological modernisation although eco-modernisation emphasises the economic opportunities provided by technological innovation and market development to achieve environmental goals, with more local sourcing of goods and services as one potential technology- and market-enabled element (Mol and Janicke, 2010, Spaargaren and Cohen, 2010).

An alternative discussion of the impact of scale comes from 'ecosystems services' that operate at the scale appropriate to natural resource systems, typically carbon or water cycles, which gives greater heterogeneity in scale.

The scale, nature and health of eco-systems services in a location could affect both the decision to adopt green technology, by providing cues which prompt action, and the impact of that technology, depending on the baseline resource availability. For example, water conservation technology may not be as readily adopted or used in an area where water appears plentiful and the eco-system appears healthy as it might be in a drought-affected area. However, scale is a highly plastic concept when considering the ways in which human behaviour affects and responds to aspects of global change and care is needed to clearly differentiate between spatial, temporal and quantitative scales (Gibson et al., 2000). Generally, this thesis will be considering spatial scale and quantitative scale (the number of households adopting a green technology).

A third aspect of scale is the way in which national policy targets, and some national incentives (such as the Feed-in Tariff - FiT), provide a framework for action, but locally distinctive approaches then differentiate what can be achieved at domestic level. An area with a large amount of social housing, for example, may be better able to organise and take advantage of the FiT because of the central decision-making functions in the social housing provider. This is the practical manifestation of some of the discussion in socio-technical transitions literature that identifies nested levels of activity which all need to be coherent in order for change to take place (Raven et al., 2012), discussed further in Section 2.1.1.

The size of the challenge of reducing resource consumption in existing homes means there is a need to have an impact across a large number of households. Also, there are specific pressures or opportunities which might be afforded to groups of households in similar places. This leads to an interest in area-based approaches to implementing household technology in order to reduce the impacts of resource use. How can working to accelerate the introduction of particular technologies in particular locations be shaped to reduce resource consumption, potentially alongside achieving other social goals?

1.4.2 Why consider place and location?

Throughout this thesis, 'place' is used as distinct from 'location'. Location defines a point on a map, an unwavering description. Place is more subjective; it encompasses the set of associations and experiences that an individual, or a group of individuals, hold for that location (Cresswell, 2009). This research draws indirectly on the literature of perceptions of the environment, place attachment and place identity (e.g. Tuan, 1990) and integrates these considerations into the concept of user attributes in the conceptual framework developed in Chapter 3.

The ways in which place, and the space-time combinations that are manifest in a location at any point, affects decision making have been explored in different contexts (McCormack and Schwanen, 2011, Owen et al., 2011), including the interaction between place and environment in financial decision making where behavioural economic geography is proposed. Behavioural economic geography includes consideration of the social roles and capacity which vary from location to location and avoids dependence on rational economic models of decision making which do not take account of the specific context of the decision, proposing instead behavioural models of financial decision making (Clark, 2010, Strauss, 2008). By including social roles and capacity, behavioural economic geography is taking elements from social practice theory, a connection which this thesis echoes (see Section 2.1.4 below).

Finally, place is emerging as a field of research within sustainability transitions literature (Coenen and Truffer, 2012, Coenen et al., 2012) and while the scale of 'place' considered is often regional rather than the local or household focus of this thesis, there is still a recognition that innovation, required for transition, will be adopted in different ways and at different rates in different locations. Researchers developing this field observe that differences between places are often over-simplified to a consideration of promotional policies and a more complex analysis of place factors would be helpful (Truffer and Coenen, 2012).

1.5 Research boundaries

1.5.1 Which resources?

Resources might include energy, water, metals, timber, forest capacity to absorb carbon dioxide, landfill capacity for waste as well as many other items. By focussing on resource consumption in the home, resources which do not flow are excluded. These are the resources concerned with the capacity to produce materials or to absorb wastes. So the field is narrowed to the resources which flow through the home and support the lifestyles of the occupiers. This narrower field might include energy, water, food resources and other consumable goods. Food and other consumables are easiest to measure or record in the form of waste.

The generation and consumption of energy, and the provision of water, provide the main areas where green technology can be applied in the home. Green technology can also be applied to other resources which end up in landfill or are recycled, notably food waste. However, reducing *consumption* of these other resources is less amenable to technology. The promotion of composting bins by some UK local authorities is a rare example. In general, the reduction of resource consumption other than water and energy is not tackled at the household level.

Considering both water and energy consumption has been problematic in light of the evidence that the relationship between reducing water use and reducing the carbon impacts of water use is far from linear (Clarke et al., 2009). Reducing water consumption is an issue of concern in the UK, firstly, because of the increasing water scarcity from over-abstraction in some areas (Environment Agency, 2008) (and the limitations this places on house building) and secondly, because heating water is the largest single element of a home's carbon footprint. In the UK, 89% of the carbon emissions associated with water use occur in the home, rather than in the providing utilities (Environment Agency and Energy Savings Trust, 2009), and therefore investigating domestic decisions to adopt technology which reduced water consumption reducing is of interest. Thirdly, moves by regional water utilities to transfer all homes to water meters, rather than properties paying flat water rates regardless of levels of consumption, are triggering campaigns to reduce water consumption and avoid the potential financial impacts on the poorest households (Bentham, 2011).

One other area of resource use which merits discussion is the energy used in personal transport and mobility. In describing how urban systems might be transformed to reduce resource use, there is often a focus on how changes in transportation systems or land use would change the environmental impacts of settlements. The factors that affect the adoption of transportation technologies are likely to overlap with, but not be entirely consistent with, the factors that affect technologies adopted in the home. The interaction between transport demand, transport capacity and land use is recognised in the UK government guidance for assessing new transport projects (Department for Transport, undated). For example, research teams have considered how changes in UK land use might alter the demand for transportation (Echenique et al., 2009). The impact on resources of mobility technology falls outside the activities in the home, and is likely to be affected by a slightly different set of factors. Therefore, mobility technologies lie outside the boundaries of this research, although it is acknowledged that the boundary is a fuzzy one! The use of domestic technology is affected by mobility and land use technologies; for example, the charging infrastructure for electric vehicles might be fuelled by distributed renewable generation such as PV cells and electric vehicles could conceivably provide energy storage for a home or area with renewable energy generation (Ekman, 2011).

1.5.2 Defining green technology

'Technology' covers a range of practices and tools. The design and purpose of technology is in itself a philosophical area. Technology is used in two senses in this research. First, it is a term which refers to specific artefacts: heat pumps, solar panels, flow restrictors etc. These artefacts have been designed with the intended purpose to reduce resource consumption or the impact of resource consumption in some way. This is technology as tangible things, and the associated skills to use those things. Used in this sense, technology is also stratified i.e. composed of components and nested in other systems (Arthur, 2009).

Second, technology is one element in a socio-technical system which encompasses household consumption of resources. In this second sense, "technology is not a driver of societal transformations but part of them" (Rip, 1998, p335). Socio-technical system perspectives, and how technology transitions take place, introduce the idea of technology genres, or technological "niches" set in "landscapes" (Geels, 2005, Geels and Schot, 2007, Kemp et al., 1998). As landscapes change, the technological niches change form and technology design and use responds.

It is helpful to think about the role and function of technology, rather than solely its physical manifestation. Technology's role might be to provide some commodity (warmth, shelter, connectedness) and to make that commodity available i.e. "instantaneous, ubiquitous, safe and easy" (Verbeek, 2005). Devices are then what deliver the commodity. Green technologies, for this research, are devices which reduce the consumption of energy or water, and devices which reduce the production of waste (energy, water or other resources).

Green technologies are intended to reduce resource use impact through different means, directly or indirectly, particularly by:

a) Reducing resource consumption (conservation or curtailment measures) e.g. flow restrictors on taps;

b) Improving the efficiency with which resources are used. e.g. condensing boilers; or
c) Substituting non-renewable resource use with renewable resources e.g. microgeneration.

Both (a) and (b) are intended to reduce the demand for all resources, while (c) reduces the demand for non-renewable resources. Appendix 1 contains a full list of the technologies mentioned in this research's case studies, together with a brief description of their function. The distinction in how a technology achieves a reduction in resource impact is often overlooked by empirical studies, with the effect that results are rarely transferable between different pro-environmental behaviours (Gardner and Stern, 2002). Efficiency investment measures can be further divided into investment and management measures, reflecting the way in which the user operates the technology (McKenzie-Mohr, 1994). A new boiler is an example of an investment measure, while replacing its control panel is a management measure.

A second categorisation of green technologies concerns the role that the technology plays as far as the user or consumer is concerned, rather than the role it plays with respect to resources. One typology, developed specifically to understand how technology might aid individuals in conserving natural resources, has four categories: determinant, intermediary, promoter and amplifier (Midden et al., 2007). These roles are not mutually exclusive. Determinant technologies dictate the way in which resources are used, e.g. insulation. Intermediary technologies provide a particular function for the user e.g. heat microgeneration. Promoter technologies provide the user with information that may alter their patterns of use, but will not do so with the certainty of determinant technologies. Smart meters that provide real-time feedback on energy use and cost are one of very few examples so far of promoter green technology. Amplifier technologies increase impacts of human activity; a computer amplifies its user's performance by offering a much greater information processing capacity than the user has alone. In the context of resource use, an amplifier technology would exacerbate patterns of use by making it easier or cheaper to use resources and therefore, by definition, these are not green technologies. A similar categorisation of technologies has been used to analyse how the impact of social networks on technology adoption varies with technology type. Dividing technologies by their technical function sets out four categories: fabric measures (walls, windows, doors and floors), visual measures (energy displays), appliances (including heating and lighting) and behavioural measures (that influence how people act within the home) (McMichael and Shipworth, 2013).

1.5.3 The roles of individuals influencing technology adoption

Technology users (householders) do not act in isolation. Work on telecoms and ICT identified six distinct types of intermediaries and different roles played along the supply chain. *"Amongst the use-side intermediaries…those involved in buying and paying for the new technology are relatively more visible than those that help people use, fix, maintain and update their technologies"* (Stewart and Hyysalo, 2008, p303). Established intermediaries might also be barriers to innovation because their services and repertoires of knowledge do not match or support the innovation.

In innovation diffusion literature, intermediaries are often taken to be the promoters of a technology. Their capacity and motivation as change agents is one of the factors that is noted as having (a small) influence on the rate of adoption of an innovation (Rogers, 2003). Change agents who share information and are expected, through a formal role or an informal network, to encourage others to adopt an innovation (Stewart and Hyysalo, 2008). These individuals are referred to as facilitators and managers in this research, and considered as a distinct role from the intermediaries who are advisers, specifiers and installers.

1.5.4 Direct and indirect effects of green technology adoption

This research is concerned with the direct effects of green technology adoption on a household's resource use. Does energy consumption reduce? Does water consumption reduce? Do carbon emissions associated with heat and electricity use reduce? Does the household reap the benefits of increased warmth or lower energy bills? These direct effects are, however, not the only effects which arise from green technology adoption. Three types of indirect effects have been identified and are outlined below, although they all lie outside the scope of this thesis, for the reasons described.

1.5.4.1 Lifecycle effects

The focus of attention for green technology is on how the technology affects resource use in the home, i.e. only during the operational part of the technology's full life cycle. The resource efficiency of a technology may be different if a fuller life cycle analysis is considered. For example, while electric/petrol hybrid vehicles achieve high levels of fuel efficiency in use, the rare metals and energy involved in the manufacture of their batteries might have a higher environmental impact than the embodied resource in a conventional internal combustion engine. These impacts have been largely excluded from this study, because life cycle impacts are not very visible to the (potential) user, and are therefore unlikely to be the most influential factors in the decision to adopt green technology. In addition, drawing the temporal and spatial boundary of the system to be considered around aspects of production or post-consumption would add a great deal of complexity, requiring disproportionate levels of research resource for the additional information that would be acquired.

1.5.4.2 Rebound effects

Rebound effects are behavioural or systemic responses to a new technology that should improve the resource efficiency with which a service is delivered. Rebound effects typically reduce the desired resource efficiency impact of that technology. There are three forms of rebound effect (Sorrell, 2007), usually applied to energy consumption but relevant to all natural resources:

- **Direct**. An improvement in resource efficiency of the delivery of a particular resource service brings down the cost of consuming that resource and enables the service user to consume more of the service for the same cost.
- **Indirect**. An improvement in resource efficiency of the delivery of a particular resource service brings down the cost of that service, giving the service user greater disposable income which can be spent on other energy services.
- **Economy-wide**. An improvement in resource efficiency provides finance and incentive for greater economic growth, which is coupled with increased resource use.

Rebound effect is calculated as the percentage of expected benefit that is lost. If an innovation is expected to deliver a 10% improvement in energy efficiency, but an improvement of 5% is actually observed, the rebound effect is 50%. A UK review of energy efficiency studies found direct rebound effects were typically 10-30% (Greening et al., 2000). A more recent US assessment has suggested that the lower end of this range is most likely (Nadel, 2012). A rebound effect might be observed in water use where, for example, low flow showers might be run for longer, particularly if the user does not pay for water use by volume. Reducing consumption of one type of resource may lead to an increase in consumption of another type of resource. For example, where water is heated electrically, such as in electric showers or dishwashers, there are a number of scenarios where reducing water consumption leads to an increase in carbon emissions (Clarke et al., 2009).

The full nature of the rebound effect is still debated. In both the British and American contexts, there is data to show that most indirect rebound effects still result in an overall reduction in resource impact, even if it is less than the original technology intervention had suggested (Holm and Englund, 2009). An evaluation of rebound effects requires collecting detailed quantitative data which this research's case study approach did not encompass. Thus the potential for rebound effects is acknowledged as being of interest when assessing the impact of technology, but no detailed assessment of real rebound effects is offered in this thesis.

1.5.4.3 Spillover effects

Spillover or catalyst effects describe the expectation that undertaking one new pro-environmental action, such as recycling, may cause people to take up further pro-environmental behaviours, which may not be in the resource domain. Where the second behaviour is more ambitious than the initial one, the spillover effect is sometimes termed the "foot in the door effect". Evidence for such effects appears to be limited (WWF-UK, 2009). Further, the number of pro-environmental behaviours adopted could be influenced by personal attributes, such as whether individuals see themselves as "pro-environmental" (Whitmarsh and O'Neill, 2010), what their values and beliefs are (Stern, 2000) and by contextual factors (such as housing type, tenure, physical geography, local policy) as well as by their existing behaviours. This multiplicity of possible effects suggests that catalyst or spillover behaviours are more complex than policy makers might hope. Another form of spillover effect is the possible impact that low carbon decentralised energy technologies might have on the form of the built environment, rather than the behaviour of households. It has been suggested that a possible impact might be that the social acceptability of design features with high insulation factors might increase if the understanding and awareness of energy generation was improved (Keirstead, 2008).

Considering the spillover potential of supply-side technology, researchers have suggested that the visibility of and engagement with a domestic microgeneration technology might change energy behaviours (Dobbyn and Thomas, 2005). Examining the adoption of PV, specifically in Austria in the 1990s, it has been suggested that adopting microgeneration was the end of a chain of energy conservation investments (Haas et al., 1999) and that where energy consumption had been initially high, energy demand was reduced by the indirect effects of the visibility of the energy supply following PV installation. The reduction in energy consumption was not observed where initial energy consumption was low.

Earlier investigations in the USA suggested only weak links between different pro-environmental behaviours, and even that consumer choices did not reflect a general pro-environmental set of values but were instead made on an activity-to-activity basis (Pickett et al., 1993). More recent studies have found evidence for consistent clustering of pro-environmental behaviours. A survey of UK consumers identified clusters as “purchasing decisions”, “habits” and “recycling”, and could relate these clusters to sociodemographic data and reported personal values which indicated different lifestyles (Barr et al., 2005). A Danish study found strong positive correlations between different environmental actions, specifically purchasing organic food, using alternative transport and recycling (Thogersen and Olander, 2006). Most of these correlations remained positive when the researchers controlled for background characteristics such as gender, age and education.

While these effects are much desired by policy makers and are interesting to think about, they have only been explored in the psychology laboratory and collecting rigorous data to investigate the extent and nature of such effects is outside the scope of this research.

1.6 Summary

In summary, this research is motivated by a desire to understand more of what would enable the most effective place-specific schemes to support the adoption and beneficial use of domestic green technologies, particularly those affecting energy and water consumption, in developed world households. The literature pertinent to the broad research topic of ‘what affects the adoption and use of domestic green technology’ now needs to be explored in order to define clearer research questions.

Chapter 2 A Literature Review to Develop Research Questions

2.1 Introduction and structure of this chapter

The previous Chapter reviewed literature describing the impact of current patterns of domestic resource use in order to provide a rationale for the research and generate a broad research arena. This Chapter contains a further literature review in two parts.

The first part of this Chapter seeks concepts with elements that can contribute to a conceptual framework for the adoption and use of domestic green technology in particular locations. Five areas of theory offering different perspectives on the broad research topic of 'what affects the adoption and use of domestic green technology' are outlined (Sections 2.1.1 – 2.1.5). Initially, elements of socio-technical system theory are reviewed in order to appreciate the range of possible actors to be considered in examining the use and impact of green technology in the home. Then three further areas of theory, diffusion of innovation, environmental psychology and neighbourhood effects, all offer further elements to feed into a conceptual framework which will underpin the research strategy and design developed in Chapter 3. The fifth area, the practice turn in social theory, complements these three but is discussed after environmental psychology as it provides insights into the degree of agency that an individual can exercise in demonstrating pro-environmental behaviours.

Secondly, empirical research studies of the adoption and impact of domestic green technology are reviewed. This review covers a range of geographies and a range of technologies operating in different ways to reduce domestic resource consumption: renewable microgeneration of heat and electricity, energy conservation and water conservation. Analysing the findings of this review highlights apparent gaps in existing research. Three gaps are described:

- the interaction of technology attributes and user attributes, particularly in the context of area-based schemes;
- the factors that affect the actual impact of domestic green technology in use compared with intended or designed impact; and

- how 'place' affects domestic green technology diffusion and subsequent impact.

These gaps help narrow the field of enquiry from the broad research interest established in Chapter 1, to a series of more specific research questions:

Q1: What factors affect the adoption of domestic green technology as promoted in area-based schemes and how does the impact of these factors vary throughout the technology adoption decision making process?

Q2: What factors shape the use, and therefore impact, of domestic green technology contributing to differences between intended (designed) impacts to reduce resource use and the actual impacts on resource use?

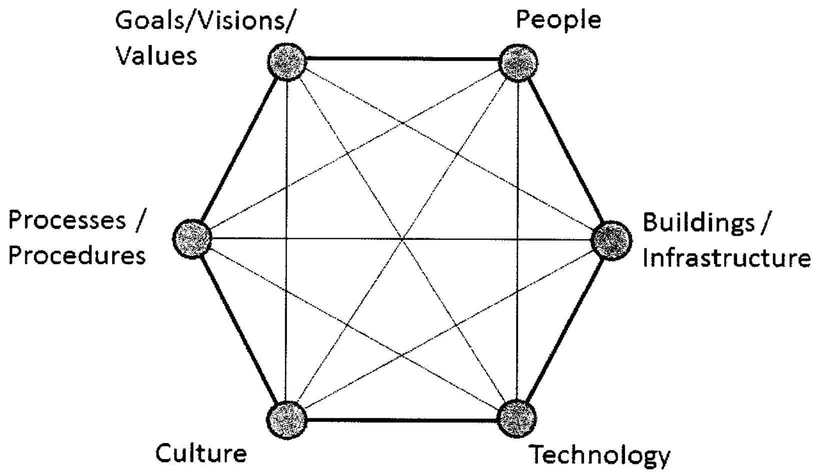
Q3: What is the role of 'place' in the adoption and use of domestic green technology?

2.2 Building blocks of theory to underpin research strategy and design

2.2.1 Socio-technical systems and technology transitions

While considering 'systems' has become an ingrained part of analytical work, specifying an interest in **socio-technical systems** highlights that this research recognises the interplay between the intended function of a technology and its design, production and use. The term 'socio-technical systems' was first coined in the late 1950s in relation to optimising workplace productivity through understanding the links between people and technology (Mumford, 2006). The intended function of a domestic green technology might be to reduce the impact of resource use in the home and this function interacts with the members of the household, or 'human actors', who are embedded in social groups which share certain characteristics such as roles, responsibilities, norms or perceptions (Geels, 2004). The homes of those individuals are set within a geographic, economic and political context. Kemp (1994) discusses why the context in which technology diffuses cannot be ignored: "Consumer tastes, lifestyles and habits are also an important part of the selection environment. But consumer tastes, preferences and the ways in which people live their lives are not autonomous factors: they are shaped by the adoption and use of past technologies" (Kemp, 1994, p1032).

A socio-technical systems approach helps the researcher identify the range of agents and actors who may have influence on the outcomes of implementing a technology. Organising actors in a structure helps with analysing the socio-technical system. An example of such a structure is the interconnected nodes of the hexagon in Figure 2.1.



Adapted from Challenger et al., 2010

Figure 2.1 A structure for taking a socio-technical systems perspective

These nodes provide different perspectives on a problem; they are not intended to create new silos which are then tackled separately. Rather, the intention is to show that changing one element of the system may change all the others (Challenger et al., 2010). In a different context, looking at how settlements as systems might change over time identified five factors (a "pentagon of place") which all needed to be considered in order to achieve a system change. The five sets of factors, which do overlap but which are all necessary conditions, are:

- Ecoware - the environmental and cultural context;
- Finware - the availability of finance and the returns that can be generated;
- Hardware - the performance of the technology itself;
- Software - the ease of using the technology and its perceived performance; and
- Orgware - the capacity of the institutions that guide the project to learn and adapt (Nijkamp and Pepping, 1998).

Both these frameworks include elements which lie outside the technology and the user. This is particularly helpful if the need to reduce domestic resource consumption is being tackled through an area-based approach. The additional elements in the framework provide ways of bringing other factors into the analysis of the adoption and use of technology in area-based schemes.

Taking a socio-technical approach also leads to some principles of design which are relevant to forming area-based schemes so that they will achieve a positive impact from implementing green technology, rather than solely considering the design of the technological component itself. The interconnection of the nodes described above is a principle that "design is contingent", there is no single optimum for all situations (Clegg, 2000). Another principle proposed by Clegg (ibid.) for socio-technical system design is that "values and mind sets are central to design", an idea explored further in the discussion of environmental psychology outlined below (Section 2.1.3).

One conceptual model developed to understand energy use in a household explicitly defined an engineering perspective (which views the household as a physical, mechanical system) and a social perspective (incorporating cultural, social, demographic, economic and psychological models) to understand the needs and beliefs that drive energy demand (Hitchcock, 1993). The author felt that this system could not be operationalised as a single model because its multi-disciplinary nature meant the variables from different parts of the framework were measured in very different ways.

An important question when thinking about a social-technical understanding of new technology adoption is how does a socio-technical system move from one state to another? This thesis seeks to add to the understanding of how homes in the developed world can move from resource intensive to more sustainable systems. The different ways in which a socio-technical system moves from one dominant technology to another has been theorised (Geels and Schot, 2007, Geels, 2005). The idea of socio-technical 'regimes' with particular technological 'niches' set in a wider 'landscape' provides a useful framework to consider the different levels at which different sets of rules and norms have influence. These 'niches' and 'landscapes' do not necessarily equate to spatial scales although the need for spatial understanding of transitions is acknowledged (Coenen et al., 2012). Transition studies often analyse the diffusion of an innovation at societal rather than the household level which is the focus of this thesis (Truffer and Coenen, 2012). Many case studies of socio-technical transitions analyse a situation at a national scale where policy and institutional context is assumed to be consistent and thus have difficulty explaining why 'niches' emerge in some local areas and not in others (Raven et al., 2012). While the issue of how to change the socio-technical regimes associated with energy consumption have received some attention due to high profile concerns related to the impact of energy consumption such as a changing climate, the same thinking can apply to transitions in the patterns of use of other resources. In Australia, where water is a constrained resource and the need to change to more sustainable water management systems is pressing, a socio-technical approach provides a reminder that the barriers to such a transition lie in infrastructure and in social norms and values, rather than in the availability of technological solutions (Bos and Brown, 2013).

Examining previous technological transitions for clues as to how a transition to low carbon technology might be achieved highlights some challenges. For example, low carbon technologies are not 'general purpose technologies', like the steam engine, the internal combustion engine or microprocessor (Bresnahan and Trajtenberg, 1995). Low carbon technologies do not (yet) create whole new swathes of functionality, rather they suggest how current functionality can be delivered with lower carbon impacts (Pearson and Foxon, 2012). Additionally, reducing the scope from all types of technology transitions to solely energy transitions provides challenges, not least the need to have policy and technology clearly aligned, and the need to allow innovation processes to follow many paths rather than focussing on single, all-encompassing solutions (Grubler, 2012). It has been suggested that transitions, changes in the 'technology regime', start from 'strategic niches' where an innovation can be implemented, learnt from and developed for wider applicability. Such niches might be in particular parts of markets, with particular groups or users, or they might be geographic (Kemp et al., 1998). It could be argued that area-based schemes to implement green technologies provide both geographic and market-based niches, focussing in one place with one set of technology users (households).

2.2.2 Diffusion of innovation

An innovation is understood as "an idea, practice or other object that is perceived as new by an individual or other unit of adoption" (Rogers, 2003, p12) thus covering all aspects of green technology. Two key measures of technology adoption can be observed and modelled. The total number of adopters is one measure. The spatial distribution of the technology is the other. Both metrics change over time.

The most comprehensive synthesis of innovation diffusion processes is provided by Rogers (2003). This suggests that making an innovation decision is a staged process moving an individual from "knowledge" to "persuasion" to "decision" (which might be adoption or rejection) to "implementation" and finally "confirmation", illustrated in Figure 2.2.

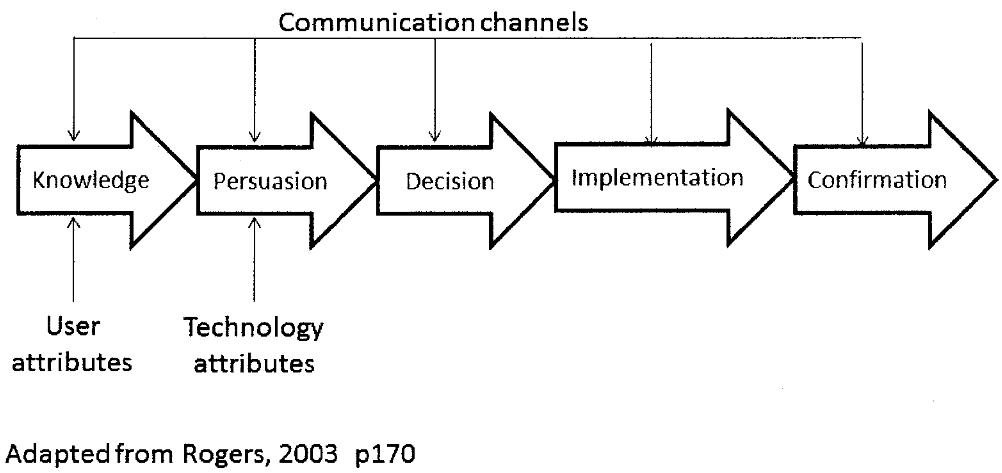


Figure 2.2 A model of five stages of the Innovation Decision Process

The number of new adopters varies over time with a small number of "innovators" and "early adopters" followed by an "early majority" to make approximately half the population, a "late majority" and a long tail of "laggards". Each of these segments of the population has a number of descriptors which Rogers uses to paint pictures of the "ideal types" of each category. Innovators are typified by being "venturesome", for example, while early adopters hold "respect" in their communities. Such descriptors are divided into the sociodemographic factors, personality variables and communication behaviours that each group might typically exhibit. Understanding the characteristics of a population and how those characteristics affect innovation adoption is of commercial interest. For example, the rapid diffusion of high tech products in a population has proved to be no guarantee of the on-going success of the producing company. This has been convincingly ascribed to the "chasm" that lies between early adopters and early majority (Moore, 1999).

The total number of adopters and the rate of change of this quantity have received considerable attention across a wide range of innovations such as public health, agricultural practices, consumer goods, ICT and the use of new technology in firms. The Bass model of diffusion developed mathematical functions which allowed new product diffusion in a population to be predicted (Bass, 1969). The pattern of cumulative adoption in a population over time has been widely observed to take the form of an S-curve with the precise gradients of the curve varying. Illustrated in Figure 2.3, the S-curve charts the cumulative number of adopters and is related to a bell curve with a long tail which charts the number of new adopters in a time period.

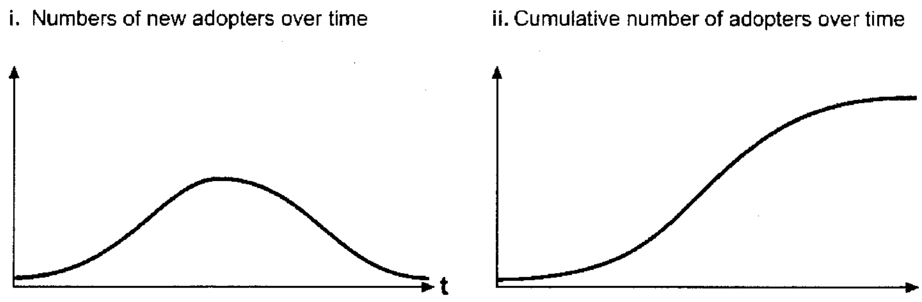


Figure 2.3 Technology adoption curves

One of the major models used to explain the S-curve is the epidemic model which is based on the idea that it is lack of information in a population that constrains technology adoption. More individuals adopt the technology as more information about technology availability, function, compatibility with existing circumstances, or more information about the effect of adoption in other places, emerges. The greater the number of adopters, the greater the number of communications channels between potential adopters and adopters which allows more information to flow (Geroski, 2000). There are, however, other explanations for the observed pattern of diffusion and other functions which can generate an S-curve. A variation of the epidemic type of model are "information cascades", where herd-like behaviour follows from an initial selection of one of a set of possible variants of a new technology (Geroski, ibid.). Another alternative is based on the needs of adopters (and their objectives and capacity) developing at different times and is more readily applied to firms rather than individuals (Geroski, ibid.). It has been suggested that the "epidemic" explanation for the S-curve might be replaced by an "economic history perspective", where the spread of an innovation is determined by previous practice in an area and among a population, or the "market and infrastructure" perspective, where the spread of an innovation is determined by the physical capabilities and potential application in a location (Brown, 1981).

The epidemic models of technology diffusion use information as the limiting factor; you cannot adopt something until you know about it. Typically technology adoption is slower than information diffusion so there must be other factors influencing (and constraining) adoption. The need to distinguish between hardware and software factors is recognised, consistent with the 'pentagon of place' described above (Nijkamp and Pepping, 1998). The suggestion is that it is not enough to have the technology and the physical setting for that technology, you also need knowledge or motivation to deploy it (Geroski, 2000).

The S-curve of adoption is usually deployed to understand the number of adopters, but not necessarily the impact of those adopters, and whether or not the adoption 'sticks'. There is substantial modelling and analysis in the microeconomics of technology diffusion, i.e. how technology diffuses at the scale of the firm, where adoption is rarely undertaken by individual decision-makers but as part of more complex decision processes involving multiple actors. For example, the adoption of energy efficiency technologies in firms has received attention (Jaffe et al., 2002, Foxon, 2003, Mulder, 2005) and the reasons suggested for their relatively slow adoption include information networks, sub-optimal cost benefit and the ways in which an organisation's systems learn to work in new ways. It is not unimaginable to extend the consideration of these factors to how they might operate at household level. There is substantial environmental policy literature assessing how different policy instruments (regulation, incentives, taxation etc.) affect technology uptake at a settlement or economic system level. This tends to evaluate how effectively technology is 'pushed' out to consumers, rather than who adopts the technology, why they adopt it and how they then use it (Murphy, 2007).

The attributes of the innovation are generally agreed to be important in determining the rate of adoption. Five perceived attributes of innovations have been extensively investigated and found to explain about half of the variance in an innovation's rate of adoption: relative advantage, observability, trialability, compatibility and complexity (Rogers, 2003). These five sets of factors are distinct but not discrete and their particular dimensions with respect to green technology are:

Relative advantage – how much the innovation is perceived as being better than the previous ways of achieving the same objectives. The perceived improvement might be in terms of cost, comfort, social status, time efficiency, etc.

Observability – how much the results of adopting the innovation are visible to others. This might be that the innovation itself is observable (for example, solar panels on a roof) or that its effects are observable.

Trialability – how much the innovation (green technology) can be tested without full acceptance. An innovation which can be tested and perhaps modified as a result of testing is likely to be more readily adopted than one which cannot be experimented with.

Compatibility – how well the innovation appears to be consistent with the needs, values, and previous experience of the adopter. For green technology in the home, compatibility will be particularly important technically: how well does the innovation fit into the home and lifestyles in that home?

Complexity – includes both the challenge of understanding and of using the innovation (Rogers, 2003, p229, p240, p258).

For this thesis, it is particularly interesting to note that Rogers suggests that technology attributes are critical to the persuasion stage (Rogers, 2003, p176), but that the user and place characteristics (such as demography) are most influential at the initial "knowledge" stage (Rogers, 2003, p174), suggesting that teasing apart the different factors that affect different stages of the decision-making process would aid understanding.

The relative advantage provided by the innovation is a particularly flexible attribute. The advantage intended by the designer (e.g. a reduction in energy consumption) may be different to the advantage perceived by the user (e.g. a reduction in energy costs and the opportunity to be warmer, or a visible display of green credentials). The value presented by the technology may even be completely unforeseen by the designer. For example, in a study which focussed on the interaction of a new technology and human values, researchers examining the impact of a new technology to support twice-daily registration in primary schools found that using the technology gave the children a sense of what the research team termed "benevolence"; the children were delighted to be able to help their teachers and the researchers

(Isomursu et al., 2011). One household technology adoption case study asserts that the rapid dissemination of the cast iron stove as a domestic heating technology in the US, an innovation which is claimed to have set America's course for energy intensive comfort management in buildings, was not due solely to economic factors (the price of firewood) but also due to the ways in which the new stoves offered multiple relative advantages. They reduced discomfort, enabled mobility and supported reliable cooking (Harris, 2008).

Another aspect of relative advantage that varies is the financial benefit conferred by the technology. While some policymakers and environmental activists see the advantage of energy efficiency in terms of a reduction in carbon emissions, the opportunity to save money on energy bills is more often used to promote energy efficiency. Even within that specific financial benefit aspect of relative advantage there is a difference between the rational criteria of marginal cost curves and the actual heuristics that consumers have with regard to comparing initial cost and running costs and to comparing any investment against a reference case which tends to increase their loss aversion (Defra, 2009).

In addition, the innovation must offer sufficient relative advantage to overcome any barriers associated with lock-in to current technologies, a factor which technology designers need to take into account when developing new products (Janssen and Jager, 2002). This is not quite the same as the compatibility of an innovation with the householder's existing systems, although the need to overcome lock-in emphasises the importance of compatibility. If relative advantage is not sufficiently attractive, then the innovation will only be adopted when dissatisfaction with the current solution reaches some threshold. In the area of this research, the absolute cost of energy bills might provide such a trigger. Framing these issues of thresholds and lock-in slightly differently, it has also been suggested that technology holds practices together, and changing technology is a discontinuity in practice which provides opportunities to change routines. However, if current practices are not felt to be unsatisfactory, then an existing technology will be retained over one that appears to have benefits (Gram-Hanssen, 2011). Thus there is both technological lock-in and behavioural lock-in with the latter also a significant barrier to reducing resource consumption (Marechal, 2010). Behavioural lock-in is explained by closer attention to a household's habits and norms, explored in Section 2.1.4 through the lens of social practice. Linked to the idea of lock-in, but more closely aligned to issues of trialability, is the reversibility of an innovation. It has been suggested that it is the irreversibility of green technology innovations in home retrofits that is a particular barrier to adoption, since irreversibility leads to different cost-benefit calculations and different risk hurdles have to be overcome before adoption (Hassett and Metcalf, 1996).

Additionally, some philosophers have suggested that technology design is shaped by the meaning of the technology as much as its function, making the attributes of visibility and observability particularly important (Verbeek, 2005). It has been suggested that it is the visibility of domestic solar technology that has made it amenable to local initiatives to promote technology, which then lead to the formation of local markets, and local variations in adoption (Dewald and Truffer, 2012).

Assigning 50-80% of the variation in adoption rates to these five factors leaves the question of what other factors might account for the other 20-50% of variance. Rogers (2003) suggests that the type of innovation decision, the communication channels available, the nature of the social system and the extent of change agents' promotion efforts are four further categories of factors but little research has been carried out to determine the relative contribution of each of these variables, particularly for green technologies. A recent exception is a study of the impact of communication channels and social networks in increasing the adoption of energy conservation measures in three community case studies. This investigation suggested that individuals who gathered information from their personal networks were more likely to adopt than individuals who received mass media or energy company information (McMichael and Shipworth, 2013). Such factors are largely ignored by technical literature aiming to support successful installations of domestic microgeneration technology. For example, recent technical advice to the construction industry offers five technology attributes:

- Building suitability – allowing the technical feasibility of the technology;
- Installation costs – inferring a relationship with the perceived value of the technology for the household;
- Maintenance – separating technologies that require user action and those that do not;
- Return on investment – taking UK financial incentives (Feed-in Tariff and Renewable Heat Incentive) into account; and
- Carbon savings (Pester and Thorne, 2011, Thorne, 2011a, Thorne, 2011b).

This set of attributes focuses on how to understand and maximise the positive impact of technology in use but does not impact on the earlier links in the innovation decision chain when the intention to adopt is being formed through the knowledge and persuasion stages (Rogers, 2003).

Rogers' development of a model of innovation diffusion is rooted in agricultural extension programmes in mid-twentieth century America. It is worth considering how these factors might be different for green technology. There is, first, the problem that green technology could be considered a negative or preventative innovation, in that the benefits it offers an adopter may be intangible. It may respond to a risk that the user is unaware of or feels unable to respond to individually, such as climate change. Analogues for this kind of innovation are mainly in health, HIV prevention and birth control. Cues may be important in assisting potential users to imagine a future without the innovation and then encourage those people to adopt the innovation and avoid that future (Rogers, 2002). In the case of adopting green technology, it may be that cues which suggest what a resource-constrained future would be like might shift consumer behaviour. These cues might be power cuts, or experiencing flood events, for example. The presence or absence of risk factors specific to a location (like being on a flood plain, having a heavily connected electricity supply, access over a bridge vulnerable to closure in high winds) may influence a user's behaviour. Equally, the presence or absence of an opportunity to exploit a resource in that location (a windy hilltop for a wind turbine, a steep beck for micro-hydro, or woodland for biomass supply) may also act as a prompt for technology adoption. These location and place issues are explored further in Section 2.1.5 below.

However, in general, such spatial aspects of innovation diffusion receive little attention in Rogers' summary. Diffusion innovation was first examined as a spatial issue (rather than an issue of density in a population) by Hagerstrand (1967). This analysis of the spread of agricultural practices (such as arable planting or the impact of a grazing subsidy in a province of southern Sweden) created datasets for the distribution of individuals, their ownership of appliances, use of transport, membership of organisations and other factors. Hagerstrand made significant advances in the development and use of datasets, highlighting such assumptions as taking an individual's home as their "average" location, when each individual will have a complex map of locations over time. Hagerstrand also observed that rapid diffusion processes are easier to analyse and understand because the researcher can assume that a population will have reasonably constant qualities over the diffusion period. Hagerstrand's motivating questions also had something in common with this research – not, "Why are things as they are here?", but, "Why are things different over there?"

The spatial analysis of innovation diffusion became part of the quantitative revolution in geography as the computing capacity to handle large datasets expanded dramatically (Brown, 1981). Analysis of innovation diffusion later took a more ideographic turn with statistical analysis complemented by case studies which took into account the context of innovation, specifically the markets into which an innovation was deployed, the infrastructure that enabled or constrained the innovation, and the capacity of the individual, household or population to adapt to the innovation (Brown, 1981).

How Rogers' conceptual model of diffusion might apply to the specific subset of technologies associated with energy conservation has been considered (Darley, 1978, Darley and Beniger, 1981). This examination concluded that economic incentives did not provide sufficient conditions to ensure that energy-conserving techniques and technologies were adopted. The economic aspects of the innovation were stratified into capital cost, perceived savings and certainty of savings, with compatibility also divided between compatibility with values and attitudes and compatibility with existing domestic systems. These authors also highlighted the importance of social networks in providing the information flows to support adoption of energy-conserving technologies. This approach was labelled a "social diffusion model", where it is suggested that the role of the change agent is critical, and an energy-conserving technology displaying relative advantage would not be adopted by the majority of potential users unless others in their personal networks had adopted the measure (Costanzo et al., 1986).

Beyond energy, the set of innovation attributes proposed by Rogers as factors affecting the rate of diffusion, complemented by factors drawn from ecological modernisation, has also been tested to see if it matches descriptions of innovation decision making by the adopters of rainwater harvesting systems as resource conservation measures in Australia. The five sets of innovation attributes did reflect the issues raised by adopters and non-adopters of such systems (White, 2010).

A framework has been developed to consider how the impact of low and zero carbon technologies could be related to their rate of diffusion in the UK and how this should inform a design approach for such technologies (Roy et al., 2007, Caird et al., 2008). This work considered how design might take into account the gap between intended design impact and actual impact created by installation, use and maintenance. The framework was also unusual because it examines the motivations and feedback from non-adopters (those who have not considered adopting low carbon technologies) and rejecters (those who have considered adopting but decided against it), as well as actual adopters. Rather than Rogers' five technology attributes, this study used a framework of technology attributes adapted from work on sustainable consumption and economic policy. This suggests four major innovation attributes where the innovation is considered within a sociotechnical system:

- Usefulness;
- Interconnectedness;
- Price; and
- Symbolism (Roy et al., 2007).

Interconnectedness is the degree to which a particular technology is dependent upon or closely linked to a range of other technologies or services. Symbolism is the meaning that the technology has for the user beyond its designed function of altering resource use. The technologies assessed included cavity wall insulation, solar water heating, PV, compact fluorescent light bulbs, central heating controls and condensing boilers. They found that the importance of these factors varied with technologies. The perception of these attributes also varied between adopters and non-adopters. The idea of 'interconnectedness' has been explored further in terms of how the impact that behavioural change, including the adoption of microgeneration and smart metering, is constrained by location and existing infrastructure (Darby, 2006).

Blurring the line between adoption and use (and impact), researchers focussing on energy efficiency interventions in the built environment have suggested that assessments of energy efficiency focus on the technical and measuring or modelling of energy use (Crosbie and Baker, 2010) but this does not address why householders reject innovations that are economically viable, or why difficult or expensive interventions might be more popular with householders than relatively simple ones. In examining householders' motivations, the same authors observe that "the benefits the different interventions bring to participants' lifestyles appear to be a far stronger motivational factor than environmental issues" (Crosbie and Baker, 2010 p74). New-build, eco-friendly houses had been purchased because they were in a desirable area, or because living in them would release more disposable income by reducing resource costs. Design and aesthetics were repeatedly noted as important to users. The authors conclude that promoting lifestyle benefits rather than environmental benefits, and ensuring that product design is user-friendly and aesthetically pleasing, is vital. In Rogers' categorisation of innovation attributes, this might be both relative advantage (improving the home) and compatibility.

2.2.3 Environmental psychology and user attributes

Continuing to consider both technology adoption and what happens after technology adoption (i.e. its use and impact), the idea that users themselves might provide the variables that affect energy use is made clear in a comprehensive review of the social factors that might affect energy use. Lutzenhiser (1993) demonstrated that individual or household energy use varies widely, even when differences in contextual variables are controlled. The ways in which opinions, attitudes, available resources (both finance and skills), age and gender might affect energy use are reflected on in this section, while the behavioural aspects of Lutzenhiser's review are discussed in Section 2.2.4 below.

Environmental psychology is a wide field. It is concerned both with how psychological factors change the way an individual takes actions which impact upon the environment, and how individuals' attitudes to the environment, local or global, are formed and changed. This review is concerned with the individual's psychological attributes as they affect the decision to adopt and use green technology in their homes. Therefore, reluctantly, it puts aside a great deal of the psychology literature that describes people's relationships with their environment, as well as the literature that delves into people's perceptions of place and how that shapes their relationship with it and their behaviours towards it. Some of the issues in this field, specifically how the physical environment and cultural environment affects perception and therefore attitudes (Tuan, 1990), feature in Section 2.2.5 where place, rather than the individual, comes to the fore. The literature which seeks to find ways to help policymakers reduce global environmental impacts (from global warming to unsustainable agriculture, with a huge range of issues between, including population growth) returns repeatedly to the interplay between attitudes, norms and behaviours as critical to designing policy interventions which will have a positive impact (Nickerson, 2003). These 'user characteristics' will be explored further below.

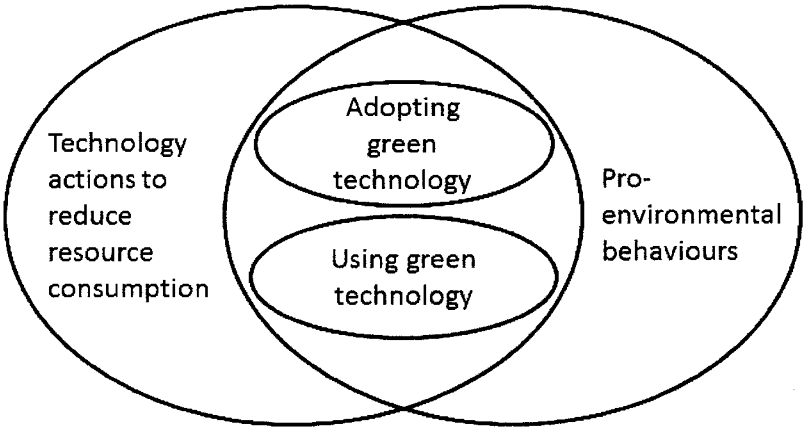


Figure 2.4 Venn diagram illustrating technology-behaviour links

Central to the exploration of this literature is the idea that adopting and using a technology are specific forms of behaviour, subsets of a much wider set of behaviours that may not require any technology, or may affect how technology is used, as illustrated in Figure 2.4. 'Pro-environmental behaviours' encompasses much more than adopting technology, including purchasing choices, recycling habits, travel or leisure choices (Black et al., 1985, Defra, 2008, Darnton et al., 2011). The purchase and adoption of technology is largely absent in literature that considers pro-environmental behaviour and sustainable consumption, although the use of such technology is discussed as part of sustainable consumption (Peattie, 2010).

The selection of a green technology for a home could be considered a type of discrete choice and discrete choice models were examined for elements that would assist the conceptual framework for this research. However, discrete choice modelling requires that a user is making a decision between a finite range of choices offering similar functionality, and this does not apply to householders' decisions to incorporate technology which reduces resource use into their homes. It is not unusual for technologies to be layered (Arthur, 2009) so that open fires co-exist with heating boilers. Microwaves and electric hobs and ovens both have space in the kitchen and the availability of electric light has not led to the abandonment of candles. Thus in choosing one green technology, all previous technologies are not displaced, meaning that any model which starts from an assumption of discrete choice would have to be heavily modified. Discrete choice models are also best when describing rational choices and the purchase of a heating system can often be a distress purchase, while adopting microgeneration or energy efficiency measures may be embedded in a wider set of decisions to do with home renovation. Discrete choice models specify the utility associated with each alternative, but in practice the green technologies examined in this research are not equivalent in function for the potential adopter or traded off against each other. These challenges are described very well by authors constructing an energy-economy model based on energy decisions made in the home (Jaccard and Dennis, 2006). Further, while discrete choice methods might, with appropriate assumptions, reflect some aspects of green technology adoption, the use of a technology after adoption is even less amenable to being considered within a discrete choice framework. However, one subset of rational choice models, **expectancy-value theories**, does offer core elements which are helpful in developing the conceptual framework for this thesis.

Expectancy-value theories seek to relate an individual's needs and expectations to their personal values and the degree to which a decision is congruent with those values. Thus these theories can help answer the question, "If pro-environmental behaviours are sought, how can they be motivated?" A review of different psychological models was included in the wide-ranging review of sustainable consumption commissioned by Defra to shape the emerging sustainable consumption and production policy area (Jackson, 2005)[1]. This review identified one of the main groups of socio-psychological theories as "expectancy-value theory", a class of theories which uses the central idea that behaviour is motivated by expectations about the consequences of that behaviour, and the importance or value individuals attach to the outcomes of that behaviour. Researchers who see pro-environmental behaviour as socially motivated tend to use a class of models known as "norm activation models" as a theoretical framework, while researchers who see self-interest as an important influence are more likely to rely on expectancy-value theories with their core of rational choice (Bamberg and Möser, 2007).

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[1] Defra commissioned a further literature review on the wider issue of sustainable lifestyles (Darnton et al., 2011) , but the Jackson review is used here because of its summary of psychological models, where the Darnton et al. review has a stronger emphasis on the practice turn in theory, explored in Section 2.2.4.

Under the umbrella of this broad class of expectancy-value theory, the Theory of Reasoned Action (TRA) (Fishbein and Ajzen, 1975), expanded to the Theory of Planned Behaviour (TPB) (Ajzen, 1991, Fishbein and Ajzen, 1975), provides a framework which can be aligned with the innovation diffusion chain from persuasion to use described in Section 2.1.1, see Figure 2.5.

The TRA adjusts the basic idea of expectancy-value theory to include the effect of social influences, particularly norms, on the intention to behave in a specific way. The TPB further adjusts the TRA to include the control that an individual believes they have over the outcomes of behaving in a specific way (the perceived behavioural control, PBC). TPB is particularly appealing to those exploring pro-environmental behaviours because it helps to explain why there appears to be only weak linkages between pro-environmental attitudes, and pro-environmental behaviours, the so-called 'value-action gap' (Blake, 1999). Attitudes are antecedents to a stage of forming the "intention to act", and therefore have an indirect influence upon action (Bamberg, 2003). TPB has been used extensively in studies of pro-environmental behaviours such as recycling, (e.g. Guagnano et al., 1986, Tonglet et al., 2004).

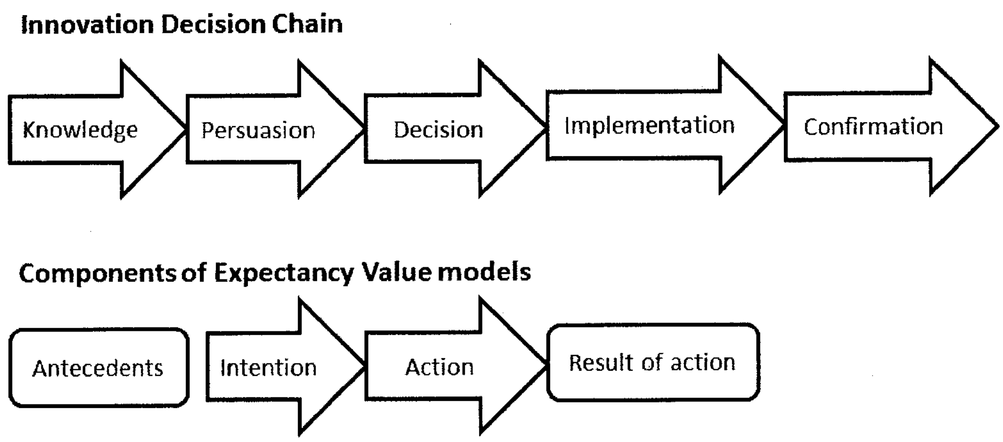
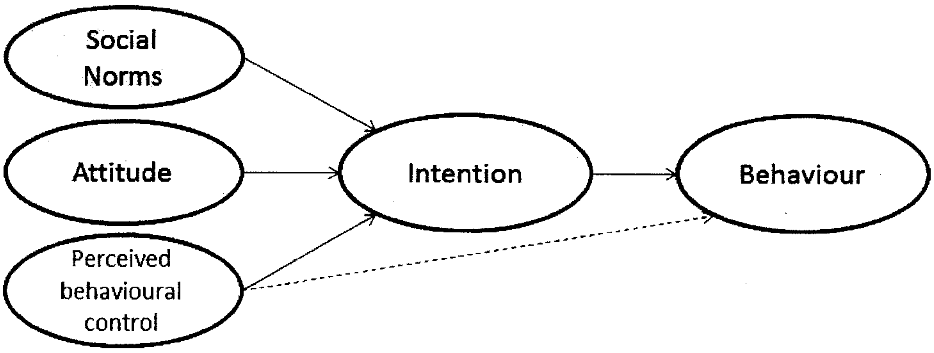
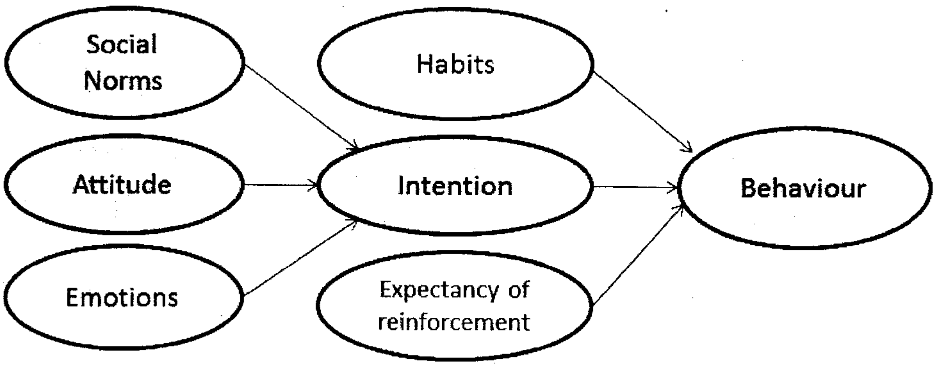


Figure 2.5 Aligning the components of expectancy-value models with the innovation decision chain

The sustainable consumption policy framework initially developed by Defra in the UK has been developed further by DECC in the areas of energy use and carbon reduction in the domestic sphere. DECC have settled upon the Triandis model of Interpersonal Behaviour as one framework to assist policy development (Chatterton, 2011, POST, 2012). The Triandis model has similar antecedents to the TPB, including both an expectancy-value construct and the impact of normative beliefs. The Triandis model also includes the influences of habit and emotion (affective factors) on behaviour. It has been suggested that the key difference between the models is the level of volitional control that an individual has when undertaking an action. The TRA and TPB suggest that most social behaviours are under the individual's volitional control, whereas the Triandis model suggests that as habitual factors increase, the individual's volition decreases (Valois et al., 1988). This makes it easier to align the Triandis model with social practice theory (also explicitly recognised by DECC, (POST, 2012)) which identifies the agency, or lack of agency, that an individual has as vital to understanding what shapes behaviour, an aspect explored in Section 2.2.4 below. Figure 2.6 presents schematics which attempt to illustrate the similarities and differences between the TPB and Triandis models.



Theory of Planned Behaviour (adapted from Ajzen, 1991)



Triandis theory of behaviour (Triandis, 1971)

Figure 2.6 Schematics illustrating the main components and linkages of TPB and Triandis models of behaviour

Reviewing relevant social-psychological models also highlighted the Technology Acceptance Model (TAM) developed from TRA specifically to explore how information technology is deployed successfully in organisations. The TAM (Davis et al., 1989) proposes that predictions of the usage and adoption of (information) technology can be based upon the factors of perceived ease of use and perceived usefulness. In the IT field, while TAM has been used to discuss and predict the likely level of adoption of an IT application, the Triandis model has been used to explore the probability of performing an act, such as using an intranet, which is a function of habits (Chang, 2004).

The most appropriate model to build into the conceptual framework for this research needed to reflect the types of behaviours that the research investigates. By taking the starting point as 'green technology in the home' and seeking a variety of such technologies, the case studies encompassed one-off 'investment' behaviours (in microgeneration technologies) as well as more routine efficiency behaviours (conserving energy or water), although most of the case studies, and nearly all the data gathered from adopters and non-adopters is in the former category. The TPB has therefore provided the most relevant elements for the backbone of the conceptual framework. However, for the energy and water conservation case studies, the additional elements of the Triandis model help to understand where the shortcomings of the conceptual framework might lie. Both TPB and Triandis models share the same spine of intention-behaviour-impact which shapes the conceptual framework used for this research (illustrated in Figure 3.1).

A further model exploring the intention to act and more specifically focussed on pro-environmental behaviours is the value-belief-norm model (VBN) (Stern, 2000), a type of norm-activation model. This model is used extensively in environmental psychology and consumer behaviour studies of the spread and use of environmental technologies and pro-environmental behaviours. The VBN proposes three linked sets of variables which produce different levels of commitment to action: the values that individuals hold, their attitudes towards the specific behaviours, and the situation or sociodemographic context. Within this framework, four broad determinants of behaviour are proposed: attitudinal factors (including values and beliefs), habits or routines, personal capabilities and contextual factors. Refinements to this list by other researchers considering water conserving behaviours (Russell and Fielding, 2010) consider beliefs separately to other attitudinal factors, in part due to Ajzen's assertion that beliefs can be a precursor to attitudes (Ajzen, 1991).

What matters is not a general but a specific attitude. If the behaviour change required is to adopt solar PV, then the required positive attitude is not "renewable energy is a good thing", "solar energy is a good thing", "my home could be a power station" or other general attitudes; it is "my home would benefit from the installation of solar PV" or "I can accept that the payback on this investment justifies the upfront costs to me". This clearly has implications for the design of research which seeks to test and compare different green technologies.

These antecedents to behaviour – attitude, PBC and social norms – are all user attributes. Other user attributes might be concerned with demography, economic situation, level of education or particular life events. In the domestic arena, the period of moving house, undertaking a major renovation, or a new baby's arrival, for example, offers particular opportunities to shape behaviour (Schäfer et al., 2012). TPB was used as the basis for assessing where moving house provided a specific opportunity to change travel behaviour. It was found that changing PBC (for example, by personalised route planning) was vital to changing behaviour after relocating (Bamberg, 2006).

The decision to adopt may be a stepwise psychological process, suggesting that some conditions have to be satisfied before others are considered. When examining householders' intention to adopt energy conservation measures, it appeared that the "intervention was first of all judged on its advantage. If the perceived advantage was minor, a potential adopter often decided to reject an innovation solely on the basis of this assessment. If the perceived advantage was high, the evaluation process usually continued; perceived compatibility then became the second evaluation criterion" (Vollink et al., 2002 p333). This may be important in considering how place affects technology adoption, in that place may not be a primary concern, but once primary conditions are met, the nature of place may have a moderating effect on adoption or use (and therefore impact).

There remains, however, a lively debate about the degree to which behaviours are shaped by attitudes and norms, or whether in fact the inverse is more likely, and attitudes and norms are shaped by behaviours. In the specific context of energy behaviours and whether energy behaviours might promote greater energy efficiency, a recent review acknowledging the importance of changing behaviours to reduce energy consumption emphasised the differences between environmental psychology research, such as the models outlined above which seek to examine what shapes behaviour, and economic research that takes a more 'rational choice' approach, suggesting that the impact of research is reduced because of the poor integration between the two (Lopes et al., 2012).

2.2.4 Social practice theory

While socio-technical systems theory provides a way of framing organisational challenges to recognise a range of actors which affect technological changes, this thesis seeks to focus more on the individual or household behaviour and decision making. The practice turn in theory starts from the perspective of the resource-consuming behaviour (eating, driving, washing) embedded in a social setting rather than from the perspective of the individual making choices or taking actions. This "patterning" (Lutzenhiser, 1993) of resource-consuming behaviours lead to a household's levels of energy and water consumption levels. These levels of consumption are derived demand, driven by actions such as cooking, washing, staying warm or cool, rather than directly consumed. Social theories that follow this practice turn point out limitations in the behavioural models of environmental psychology, such as TPB, noting that the agency of the individual is limited. Rational choice is severely constrained. Changes in resource consumption will only be achieved through changes in the social systems that constrain individual agency, the social norms, habits and practices that may be led by technology, or may provide the impulse for technological development. Using a social practice approach moves the focus from an individual's attitudes and choices to how practices can form, stabilise and then morph or cease. The question, 'How can energy demand be reduced?' becomes 'What would influence householders to move to more sustainable practices?'

The way in which cultural practices change, and therefore affect resource use, has been explored in the context of domestic water and energy demand (Shove, 2003, Gram-Hanssen, 2010). This sociological exploration of what drives resource use highlights how standards and expectations of personal cleanliness have meant that water used for bathing has increased from nil in the late eighteenth century, to one bathtub per week five decades ago, to water for two showers a day today. Laundry practices have altered a great deal over the same time; laundry water, and laundry detergent, use have increased many times over as expectations change. This is not purely an individual behavioural issue; there are cultural norms which are driving individual behaviours. The relationship between technology, routines and consumption is not unidirectional. The availability of technology can change routines (and therefore consumption) and where resource consumption varies by up to 100% for similar houses, the householder's attributes in terms of cultural background and norms established in childhood are very important (Gram-Hanssen, 2008). In thinking about the energy use inherent in particular building designs, a practice-oriented approach highlights that personal comfort has psychological as well as physiological dimensions (Cole et al., 2008) and can be achieved by many means other than the highly-designed and mechanised routes of heating and air-conditioning. Thinking about whole buildings and their surroundings in such a way that space can be configured, controlled and used in different ways, cooling people rather than cooling the house in order to achieve personal comfort, opens up new opportunities to reduce resource use (Cooper, 2008).

The social shaping of resource use, particularly of energy and water, has been of interest to social practice theorists (e.g. Shove, 2003, Shove, 2009). Researchers have applied social practice theory to investigating a workplace programme to encourage pro-environmental behaviours (Hargreaves, 2011a). This revealed how workplace practices are shaped by many factors other than the individual's attitudes to the environment, factors which are interdependent, such as health and safety responsibilities, expected standards of self-determination, and the image that individuals wish to portray. This is a helpful reminder that practices of consuming energy or water, the focus of this research, do not exist in isolation but form part of a bundle of connected practices that make up home lifestyle. There may be triggers where a change in circumstances or lifestyle leads to adoption of a new technology. The window of opportunity provided by, for example, relocation or changes in personal circumstances like arrival of a new baby, is recognised as a limited period when changes can be made to norms and habits (Marechal, 2010, Bamberg, 2006, Gram-Hanssen, 2011).

Social practice theory is far from achieving dominance in exploring resource consumption. This is an evolving area, where recent research initiatives have been characterised as "Energy, Technology and Society", investigating forms of resource provisions such as renewables and microgeneration, or "Society, Energy and Technology" (Janda, 2009). While this thesis may be closer to the Energy, Technology and Society camp, it has still been informed and shaped by social practice theory.

There is scope to connect social practice theory to innovation diffusion theory. How a potential adopter evaluates a pro-environmental technology will be affected by how the potential adopter sees their own lifestyle practices and priorities (Axsen et al., 2012). The technology attributes may support or resist 'domestication', which encompasses both the adoption of the technology and its use as part of everyday life. A new technology needs to be compatible with existing practices to become adopted, but then, once adopted, the technology itself changes practices. In ICT, for example, a mobile phone may be adopted by an individual who wishes to be able to make emergency calls, but then owning the phone leads to receiving SMS text messages and this changes the user's practices as they become adept at texting (Lehtonen, 2003).

2.2.5 Neighbourhood effects

It is noted in Section 2.1.1 that much of the analysis of the diffusion of technology is aspatial. Examinations of the diffusion of energy technologies using technology transition perspectives have included compact fluorescent light bulbs and, initially, solar PV, deploying relative spatial analysis rather than an absolute framework. The spatial extent of a technology's adoption was from an innovation's core or emergent area, to a wider extent and then out to a periphery. The locations are typically national. Denmark, for example, is the core for wind turbine technology (Wilson, 2012). This research also suggests further sets of variables beyond technology attributes and user attributes, such as the market characteristics and production capacity for the technology. At this very large spatial scale, differences in energy behaviours have been compared between countries, and linked to different national cultural attitudes and values (Swim and Becker, 2012). This analysis suggested that national differences might arise because government and business policies provide the context for residents' actions, and that all actors are working with broadly similar values so that the influence is not unidirectional.

How else might place (or location) affect a household's decision to adopt and use green technology? Returning briefly to aspects of environmental psychology, the configuration of a neighbourhood, its history or the 'natural capital' provided by landscape characteristics may affect the way in which its inhabitants feel about that neighbourhood (Stedman, 2002). The degree of identity or place attachment bound up in a location might alter the inhabitants' propensity to consider green technology through shaping their environmental attitudes if they connect that green technology with conserving an aspect of their local environment that they appreciate (Uzzell et al., 2002). For the range of green technologies considered here, the connection between individual household adoption and conserving valued place attributes is not direct or unambiguous, so it seems unlikely that the physical attributes of place will have a strong connection to adoption rates through this route.

User characteristics, and in particular a householder's self-perception as it interacts with their desire to settle in a particular neighbourhood because it is 'their kind of neighbourhood', were incorporated into a model which recognises that there are long term (location choice), medium term (appliance choice) and short term (appliance usage) decisions which affect household energy consumption (Biying et al., 2012). This model chose to reject the usual unidirectional causal assumption that households and individuals locate themselves in neighbourhoods and then, based on neighbourhood attributes, undertake their energy consumption behaviours. It described instead a 'self-selection effect' that households select a neighbourhood and are then more likely to own some kinds of appliances or spend more resources in ways that accord with their chosen lifestyles. The model developed considers household energy use for transportation. It is possible that parallels might be found in the household behaviour of adopting microgeneration, i.e. people self-select properties which have the potential for microgeneration because they are interested in installing microgeneration at some point in the future.

At an early stage in this research, it was considered whether a typology of places of a much smaller scale than national might be helpful in identifying where particular green technologies might have the most beneficial impact. There are myriad place typologies available and policymakers often create bespoke typologies for particular purposes. Typologies might be classifications, indices or nearest neighbour models (Lupton et al., 2010). In very simple terms, indices allow for ranking by variables of interest, classifications provide groupings of settlements which exhibit similarities, and nearest neighbour models are powerful for benchmarking since they compare places that are most alike, as measured by the variables of interest (Lupton et al., 2010).

Some useful ways of considering how place affects behaviour and (policy) outcomes comes from the 'neighbourhood effects' literature. Recognising that social policy needs and impacts vary between different geographic communities, the literature of neighbourhood effects examines less what the mechanisms are for area-based impact, and more what the apparent influencing factors appear to be. While neighbourhood effects is largely concerned with understanding social problems and what drives different types of deprivation in different areas, and therefore understanding the different policy and support that needs to be provided to unpick those problems, the literature has been reviewed in order to identify distinctive place-specific factors which lead to place-specific activity. A recent review identified fifteen such mechanisms (Galster, 2010), of which several might be considered pertinent to green technology adoption. These include the effect of the quality of a neighbourhood's physical environment, the strength of local social norms, the strength and quality of social networks, the impact of stereotyping and stigmatisation on a neighbourhood's perceived capacity to act and exposure to toxins in the local environment.

Social exclusion policy research offers three distinct groups of 'characteristics of place' which each moderate the 'neighbourhood effects' in different ways (Lupton and Power, 2002). These three sets of characteristics are:

- Intrinsic characteristics. These might be the physical attributes of a place;
- Population composition and dynamics. The sociodemographic factors; and
- Acquired characteristics, such as local authority policy, housing density, community cohesion, or transport networks.

These categories are not independent or mutually exclusive. This is a useful way of distinguishing between the different place factors that affect green technology adoption. The three sets of characteristics overlay reasonably well onto three sets of variables used by researchers in Canada seeking to understand whether place played a role in a community's propensity to take environmental action (Wakefield et al., 2006). In this case, the framework's three dimensions were:

- Contextual (the neighbourhood environment, which could be either intrinsic or acquired, in Lupton and Power's terminology);
- Local compositional (individuals' characteristics, taken in aggregate); and
- Collective (the strength of social networks).

Exploring whether community ownership affected public attitudes to wind energy, Warren and McFadyen (2010) found that there was a more positive attitude towards wind energy in all populations than had been anticipated, but that approval was strongest where there was also community ownership of the wind energy scheme. Approval was subject to some limits, notably what was deemed appropriate in the landscape. For example, on the small, community trust-owned, Scottish island of Gigha three wind turbines were welcomed by the community, but only a couple more could be considered. For this community, the degree of visual impact, as well as subjective views on absolute impact, was important. The place factor on Gigha that enabled community ownership was the existence of strong community cohesion following a buyout of the island, the first in a wave of Scottish land reforms. This suggests a sub-category of acquired place factors: the capacity in a location due to local institutions, ownership and governance of those institutions and local assets, and the conduits for investment in community futures. The local institutional capacity has been identified as an important enabling feature for area-based schemes (Dawson et al., 2011).

There might also be particular cues to action in a particular place. In examining the decision to install dual flush toilets as a water conservation device, Lam (2006) found that the intentions to act were increased when people believed they were vulnerable to drought. This was considered a "contextual factor" in following Stern's value-belief-norm model. Contextual factors appears to be the area where place or location-specific effects might lie, but psychologists examining pro-environmental behaviours and attitudes have suggested that "contextual factors have not been examined systematically, nor are contextual factors included in the theoretical approaches [including TPB] ...the TPB only considers individuals' perceptions of contextual factors, as expressed by perceived behavioural control" (Steg and Vlek, 2009 p312). 'Perceived efficacy of action' might also have bearing on whether or not people adopted pro-environmental behaviours (Lam, 2006). For example, a propensity to recycle might be decreased by a belief that separated waste was recombined or sent a very long distance to be recycled, incurring considerable environmental impacts from transport.

For some green technologies, particularly for microgeneration technologies, there are place-specific aspects which determine whether a technology can feasibly deliver the desired outcome. Incident solar energy on an area will affect the feasibility of solar water heating and PV cells, for example. However, technical feasibility alone was not a sufficient predictor of solar technology uptake in the US, as reported in a 2008 study. A technology needed to be technically feasible, but also socially feasible and aligned with local policy and politics. The authors speculated that this might be a stepwise decision without being certain about which steps followed which (Zahran et al., 2008).

All the theories presented above contain ideas which are helpful in exploring the adoption, use and impact of domestic green technologies, but none offer a complete framework to address the research arena identified in Chapter 1. Before attempting to design such a framework and a research approach, the next section, Section 2.2, considers if and how the various concepts described above have already been used in studies of green technology diffusion.

2.3 Empirical studies reporting the adoption and use of domestic green technology

This Section examines studies of green technology adoption in order to assess which of the factors identified in Section 2.1 as influencing the adoption and use of domestic green technology have already been supported by empirical research, and which factors are not fully researched. As the next Chapter will show, this research has proceeded by collecting data from a series of technology case studies, each unique in its combination of physical geography of the area, and technology being deployed. The existing empirical work that has been found is therefore organised in a similar manner, by technology. Microgeneration of heat and electricity, resource conservation through appliances and behavioural approaches, and energy efficiency improvements through technology are all explored. Before this, studies which look at the underpinning factors of what drives consumption are introduced so that these different modes of reducing resource consumption through technology are placed in context.

A recent meta-analysis of empirical investigations into ways of promoting pro-environmental behaviour (PEB) excluded studies which focussed on technology adoption but did note that where improvements to domestic energy efficiency used to centre on capital investments such as heating, insulation or appliances, the scope for PEB triggered by inexpensive technology-based actions such as compact fluorescent light bulbs, low flow showerheads and tap aerators needs to be explored (Osbaldiston and Schott, 2012). It is hoped that the case studies presented in this research make a contribution to that identified research need.

What drives consumption?

A conceptual framework developed to evaluate what determines urban resource consumption (energy consumption, water consumption, carbon intensity of travel, domestic appliance purchases), identified three groups of geographic attributes: household context, dwelling context and locational context, alongside two groups of individual attributes (Newton and Meyer, 2012). This framework did not attempt to include technology attributes, focussing instead on behaviours across the use of a wide range of technologies with different functions. Using the framework to analyse the results of 1250 postal surveys in Melbourne, Australia, dwelling characteristics and household characteristics (rather than individual characteristics) were found to be linked to levels of resource consumption. The effect was not solely on the basis of dwelling size and age, but on the lifestyles that particular locations were configured to support. For example, a new, high-rise neighbourhood designed to support professionals who might be in the city for some periods but out of town for weekends and holidays had a high per capita consumption of resources despite a high density and lower per capita area footprint. The link between residential energy consumption and building or urban form has been modelled in other locations, comparing energy consumption between houses which are single or multi-family homes, and between different configurations of housing, with the main finding that larger houses demand more energy regardless of how houses are grouped (Liu and Sweeney, 2012). There are other studies which explore the potential drivers and variables which correlate with energy consumption, rather than energy-conserving behaviours. For example, a recent US study confirmed links between affluence, age and consumption, but also suggested spatial variations in consumption patterns because of housing form or associated lifestyles such as suburban locations requiring commuting to employment (Sanquist et al., 2012). Other research has examined the apparent impact of these variables when different support is provided in terms of feedback on energy consumption, finding that positive environmental attitudes are most helpful when combined with in-home, computer-based consumption feedback (Brandon and Lewis, 1999). However, these studies have less to offer a conceptual framework of green technology adoption where adoption is a one-off behaviour, followed by on-going behaviours which comprise use of that technology.

2.3.1 Microgeneration – heat and electricity

Some analysis has looked at technology adoption across a range of microgeneration technologies, for example examining the effects of one particular user attribute, such as age. It has been identified that while older households, on the basis of expressed willingness-to-pay data, did not have any particular preferences or biases in the choice of primary heating system (cost was the main technology attribute that affected the choice) (Scarpa and Willis, 2010), older households were much less likely to adopt novel microgeneration technologies (heat and electricity) (Willis et al., 2011). These results concerning age are broadly consistent with another willingness to pay study in the Republic of Ireland (Claudy et al., 2010). As the demography of the UK shifts towards an aging population, the effect of this particular potential user attribute suggests that capital costs of microgeneration will need to reduce significantly if uptake is to increase. The reasons why this pattern is found are not explored in any detail, although it does accord with the general characteristics of the 'ideal type' of the late adopter. However, it may not be absolute age, but rather the learning and habits from being born at a particular point in technology development, which is the main influence on a reduced willingness to pay.

In the UK, domestic green technologies, both microgeneration of electricity and heat, were promoted through grants supplied by the Low Carbon Buildings Programme from 2006 to 2008. An evaluation of this Programme focussed on the changing costs and benefits of installations during the programme rather than adopter experiences. However, this evaluation did highlight the important role of the installer in achieving a successful installation and noted regional variations in both application and installation rates, speculating that these variations might be caused by a combination of technology factors (efficiency and effectiveness under certain environmental conditions) and the maturity and experience of the installer and supply chain (Bergman and Jardine, 2009).

One research group has gathered user and installer perceptions of green technology in the UK through a number of investigations, some jointly with the Energy Savings Trust. Their first report examined both energy efficiency products (described in this research as energy efficiency investments, Section 2.2.11 below) and renewable energy technologies – microgeneration of both heat and electricity – although the vast majority of installations in that first report were solar thermal systems. This wide-ranging report also took

Rogers' innovation diffusion as its starting point and gathered information from adopters, non-adopters and energy professionals, working with data from questionnaires and a large sample size (the second stage survey elicited 390 responses from adopter and non-adopters). The analysis from this research focussed on how the technology design might be improved in order to increase positive responses from users and accelerate the rate of adoption (Caird and Roy, 2008, Caird et al., 2008). The model of adoption developed differs from the conceptual framework proposed in Chapter 3 below in how user attributes are partitioned, and in addressing issues of place or location (Roy et al., 2007). Further studies by this group focus on particular technologies and are reported below.

2.3.2 Microgeneration – low carbon heat

Collecting and analysing the views of approximately 550 UK early adopters and 350 'considerers' (non-adopters) of renewable heat microgeneration (solar thermal systems, heat pumps, biomass boilers), householders showed a marked preference for technologies which were well established and compatible with their properties (Roy et al., 2008, Caird and Roy, 2010). The early adopters were usually in rural properties off the mains gas grid, where gas heating remains the most cost-effective form of space heating in the UK. The early adopters in this survey were not the most affluent, but they did self-report high levels of energy and environmental awareness, concerns which were reflected in the other lifestyle choices they took such as preferred mode of transport.

An evaluation of a Swedish scheme offering financial incentives to upgrade domestic heating systems included analysis of the factors that affected the adoption of heat pumps and biomass stoves among early adopters. This analysis found that relative advantage (or "perceived advantage"), primarily in terms of the comfort delivered by a heating system, was the main factor in determining adoption, and that this perceived advantage varied spatially. Therefore adoption varied spatially, although the reasons why this might be so were not explored. This study also identified installers and personal sources of information as the most important communication routes for adopters, and found that potential adopters gave a higher priority to the on-going operating costs of a new heating system, above the initial investment cost (Mahapatra and Gustavsson, 2008). An evaluation of a similar subsidy scheme in Norway tested the hypothesis that user satisfaction would be a function of economic return on investment and technical performance of the technology but found no correlation between these two variables. Technical performance in terms of comfort provided, and the cost of electricity, appeared to be the factors which explained user satisfaction (Bjørnstad, 2012).

2.3.3 Heat pumps

A UK field trial of heat pump (ground source and air source) performance also collected questionnaire data on user perceptions from the households whose heat pumps were being studied in the technical trial (Caird et al., 2012). The survey respondents in this trial reported a good level of understanding of the heat pump's operation, and a high level of satisfaction with fault-free running. However, one in five respondents reported intrusive noise in operation, and nearly a quarter of heat pump users felt they could not always heat rooms to the desired temperature, suggesting that the 'relative advantage' offered by heat pumps as an innovation in space heating is questionable. Technical performance of ground source heat pumps in small social housing units in north Yorkshire has been monitored (Boait et al., 2011) and recommendations made as to the sizing and control features needed for the technology in the UK retrofit market, but this assessment did not include any data from users.

2.3.4 Solar thermal

As solar technology started to emerge for general domestic use, researchers set out an agenda for considering the adoption of domestic solar energy in the US as an innovation diffusion issue. This investigation suggested that the demography of potential adopters and the potential adopters' perceptions of the attributes of solar thermal technology needed to be understood. These dimensions were explored through analysing responses to a mail questionnaire carried out in the State of Maine (Labay and Kinnear, 1981). This research was extended and largely confirmed by analysing responses to a mail survey of Californian householders (Guagnano et al., 1986). These authors explored how Rogers' attributes of an innovation applied in the case of solar technology. They found a good degree of fit, while acknowledging that the five factors (relative advantage, trialability, observability, complexity and compatibility) do not describe *why* the perceived attributes of an innovation elicit the response they found in potential adopters, and that the psychological dimension of decision making is largely absent from Rogers' model. More recently, the spatial distribution of solar heating systems in the US has been analysed using GIS-based methods, finding that the technical characteristics of the solar heating systems, and the affluence and dwelling density of the area were the main factors explaining the adoption of the technology (Zahran et al., 2008).

A Greek study of the factors that drive the adoption of solar thermal technology used a variety of focussed questionnaires for different populations and interest groups and found regional differences which the authors ascribed to a variety in building stock and home ownership patterns. This study also found that nearly one fifth of solar thermal adopters had experienced problems with their system's operation. Overall, solar thermal technology was considered "modern" and therefore "good" by the majority of those interviewed. Thus the perceived attributes of the technology, as well as the performance attributes of the technology, played a role in adoption (Sidiras and Koukios, 2004).

A postal survey of German households examined data from over 12,000 households, of whom 2.97% (356) had solar heating for space or water heating. Using an agent-based model to examine the data, this study found an interaction between location and technology (where solar radiation is higher, there is a greater propensity to adopt solar thermal technology) but did not identify any correlations between household characteristics and solar thermal adoption. The low in-home financial benefits of the technology were a barrier to more widespread adoption (Mills and Schleich, 2009).

In the UK, domestic solar power has been examined as a case study in the diffusion of innovation, collecting data from 100 early adopters of solar systems and 1000 adopters of other types of energy efficiency measures, who might be classified as early majority. This case study found significant differences in the users' perceptions of solar technology depending on whether they were early adopters or early majority. Many of these differences were linked to a level of knowledge about solar technology which might be ascribed to learning through experience. One finding was that the perception of a potential cost benefit was stronger in the early majority (non-adopters of solar thermal technology at this point) than in the early adopters (Faiers and Neame, 2006). These researchers extended their data analysis and proposed further that different categories of users assessed innovation in different ways, specifically, innovators did not evaluate the observability of solar thermal systems (Faiers et al., 2007). This study also found that the most innovative users were not in the higher income brackets, implying that financial benefits may not be the most important aspect of the technology for innovators. However, the nature of relative advantage changes as the innovation is considered for adoption by other segments of the population (i.e. the importance of different technology attributes changes as the technology becomes more widespread)(Moore, 1999).

2.3.5 Biomass

While data from only two households using biomass heating systems was collected for this thesis, there are a number of studies which report on user experiences of biomass systems as novel and renewable heating technologies. These are principally from Scandinavia where topography makes a mains gas network impractical outside major settlements and biomass is already a well-established resource with wood-burning stoves (using logs) making a significant contribution to the valued cosiness of a home as well as to space heating.

The municipality of Oslo, in Norway, offered grants (up to 30% of installation costs) to allow switching to low emission stoves for space heating, partly motivated by a desire to improve local air quality. A mail survey (n=808) examined consumers' perceptions of their biomass heating (all those surveyed were recent adopters) and used TPB as a framework for analysis. The results demonstrated strong satisfaction in using the stove (on comfort and economic grounds) but most respondents felt that their stoves were neutral with respect to benefitting the environment, which suggested that user concerns about the environment may be less important than user concerns about the cost of heating. Positive sentiments towards handling firewood and using the new stove did not outweigh the negative impact reported about the time and effort spent in operating the stove. Consumer perceptions after adoption were focussed upon the operational attributes of the technology, rather than any relative advantage it provided in terms of warmth, cost reduction or environmental benefit (Nyrud et al., 2008).

Norwegian households' adoption of wood pellet heating has been studied from an innovation diffusion perspective. User capacity to understand and use the technology, which would be a component of PBC in the TPB, is the major barrier to adoption. Norms and values have only indirect and minor influence, implying that in this case policy action should focus on the technology infrastructure and observability rather than trying to alter norms and values (Sopha and Klockner, 2011). Also in Norway, the satisfaction of early adopters was found to be linked to technology attributes: both the initial costs and the technical performance of the heating systems (Skjevrak and

Sopha, 2012). A further mail survey (n=960) focussing on user attributes found that while adopters of wood pellet heating had many of the attributes of early adopters, and non-adopters had many of the attributes of late adopters, the results for income level and education contradicted what is predicted from theory. Biomass stoves were adopted by lower income households than expected. Further analysis of this data found no significant difference in pro-environmental values between adopters and non-adopters, but suggested non-adopters needed a much higher subsidy (up to 64% of installation costs) to be persuaded (Sopha et al., 2011).

An exploration of what potential adopters thought about wood pellet heating systems in Finland (n=81) found no evidence that trialability or observability featured in consumer decision making to adopt this technology. The author speculates that this might be because the adoption of a new heating system is high and not very reversible (Tapininen, 2008). Also in Finland, researchers developing a model to examine the choice of heating systems found that the utility of the system (related to the relative advantage it offered) was a function of cost, effort needed to install it, quality of the system, household characteristics, spatial issues such as distance from biomass source, and what the researchers term the “diffusion effect”, or the degree to which other households’ behaviour affects the household under consideration (Kasanen and Lakshmanan, 1989).

A UK study of early adopters of microgeneration included automatic pellet-fed biomass room heaters or stoves. The profile of adopters is broadly one of environmentally aware individuals in large rural properties off the gas grid who have experience of solid fuel or LPG heating. However, this research also found that compared to GSHP adopters, individuals were more often self-employed or involved in farming, which sometimes gave them ready access to a woodfuel source. Price and effort of commissioning and operation were the main reasons cited by non-adopters. All adopters would welcome better supply infrastructure for pellets (Roy et al., 2008).

2.3.6 Microgeneration – renewable electricity

Framing microgeneration of electricity as a “resistant innovation” rather than a receptive innovation, and therefore assuming that adoption of microgeneration would be slow, a survey of consumer attitudes in the Republic of Ireland found significant differences in consumer awareness of different technologies, with awareness a necessary precursor to adoption. Awareness of technologies also varied with location although the reasons for this variation were not investigated. There was speculation that variations might be due to differing marketing efforts, or simply a difference between urban and rural populations, with rural populations being more aware of microgeneration since there may be more opportunities in the configuration of buildings to adopt microgeneration (Claudy et al., 2010).

2.3.7 Photovoltaics (PV)

Comparing a number of schemes in Germany and Switzerland, research into early PV adoption for domestic use examined different programmes intending to act as catalysts to increase the level and impact of adoption. In effect, this analysis considered the factors that affected the intention to adopt in potential adopters outside the initial catalyst programme. This research suggested that the impact of the catalyst programme was a function of the financial incentives provided, the human actors and their motivations, the penetration of the programme (in absolute numbers and in "intensity" of involvement), the distribution density of the PV after the catalyst scheme, and the "history", a broad, location-specific context that recognises that schemes are not implemented in a vacuum and that policies and public attitudes have a bearing (Berger, 2001).

A Dutch study used a questionnaire to elicit the motivations of PV early adopters, drawing on Rogers' innovation diffusion description, and on the TPB. This study also looked at the effects of running information sessions for prospective PV adopters as a specific intervention in the town in focus, a form of acquired place factor. This study found the five factors outlined by Rogers were dominated by relative advantage, with the technology's attributes providing little opportunity for trialability. This study also found a link between the provision of area-based information sessions, and a reduction in a potential user's assessment of the complexity of PV technology, suggesting an area-based approach can change the perceived characteristics of technology and therefore influence the move from intention to adopt and adoption (Jager, 2006).

At the end of the 1990s when PV was still a novel and expensive technology, it was assessed for its potential to become more widely adopted by utility managers as an energy source with a substantial role to play in the energy distribution network of the US. A combination of three user attributes: "motivation, experience, and familiarity", were found to be limiting (Kaplan, 1999). While "motivation" includes elements of attitude from expectancy-value models, "experience and familiarity" could be considered the results of the technology's attributes of observability and trialability. Thus there are conceptual links from this finding to both innovation diffusion and models like the TPB.

Examining the spatial distribution of residential PV in the USA and looking for correlations between the numbers of PV installations in a postal (ZIP) code and the demographic data assigned to that postal code suggested that technical considerations did not dominate the decision to adopt. The top two states in terms of coverage of PV installations across ZIP codes were New Jersey and Connecticut, with California third. New Jersey and Connecticut are in the bottom ten states when ranked by technical solar power potential. Alongside solar potential (an intrinsic characteristic), the financial incentives available, the cost of electricity (both acquired place characteristics) and the age profile of the ZIP code (a demographic place characteristic) were found to be the most important variables associated with PV adoption (Kwan, 2012).

An in-depth interview and questionnaire survey of one sixth of all UK domestic PV installation owners in 2004 (n=118) confirmed that the innovators for PV were affluent, older, educated house owners (Keirstead, 2007). In the UK, the introduction of the Feed-in Tariff (FiT) in 2010, and the subsequent rapid adoption of domestic PV systems has been explored as a case study (Cherrington et al., 2012), although this case study only considered the impact on households of projected changes to the FiT and did not explore the adopters' and non-adopters' non-financial interests. Modelling the FiT found that PV would still be financially attractive to potential users after the FiT had been reduced.

Other researchers have examined the behavioural responses to PV installations. An Austrian survey of PV adopters and non-adopters asked two questions, 'What motivates consumers to invest in PV?' and, 'Does the presence of a PV system lead to energy conservation and changed behaviour?' Analysing the survey results, the authors suggest that installing PV is the final stage in a "conservation chain" of efforts undertaken only when energy efficiency gains have been made (Haas et al., 1999).

2.3.8 Water conservation

In Australia, water scarcity and drought is an matter of concern and several Australian studies have explored issues of attitudes towards water conservation and how to embed water conservation measures in the built environment. Seeking to understand how location attributes might play a role in attitudes and behaviours, a comparison between an urban area with water surplus and a rural area that had experienced drought, treated 'experience of drought' as a location factor rather than an attitude factor. This comparison found that while both areas understood the need for water conservation, the residents of the drought-affected area took significantly more actions to reduce water consumption, i.e. the intention to adopt may be similar in both locations but actual adoption was stronger where there was actual experience of drought (Gilbertson et al., 2011). Another Australian investigation agreed that regional variation, where regions varied in the degree of drought experiences, did have a significant impact on water consumption, but also found that demographic factors accounted for the greatest variance in water consumption behaviours (Fielding et al., 2012). The experience of drought might lead to water efficiency investment as well as water conservation action. In examining the decision to install dual flush toilets as a water conservation device in Taiwan, Lam found that the intention to act was increased when people believed they were vulnerable to drought (Lam, 2006).

Another examination of the drivers of water conservation behaviour in Australia focussed on user attributes. A sample of 3094 was constructed by selecting half from an internet panel demographically representative of the Australian population and selecting the remaining half from eight locations with unique water situations. A pool of hypothesised factors drawn from previous studies included environmental awareness, information, gender, age, having experienced drought and perceived cost benefits. Two user attributes emerged as important: a high level of pro-environmental behaviour and pro-actively seeking out information about water. However, the authors state that the attitude–behaviour link is known to be weak for water, suggesting that water conservation behaviour is a sub-set of other pro-environmental behaviours pursued by the most motivated (Dolnicar et al., 2012).

An exploration of how psychological variables, specifically personal values, and demographic factors affected water consumption in Brazil analysed 400 responses from inhabitants of one city and found that gender was unimportant; increasing age made individuals more careful with water consumption; and increasing education was *inversely* proportional to awareness of environmental issues. The authors suggest that this might be because increasing education leads to greater income, which leads to less concern about the need to be careful with resources from a financial perspective. Greater environmental awareness led to less "wasteful habits" of water use (Pinto et al., 2011). While the pattern of consumption is not unusual (affluence allied with greater consumption), linking this pattern through the variable of level of education is novel.

The geography of these studies is notable in that they have been carried out where water scarcity is or has been an issue. Despite the relative water scarcity in some parts of the UK, no similar UK studies of the factors that affect water conservation technology adoption have been identified, although the UK water regulator has noted that water companies could do more to reduce domestic water use (OFWAT, 2011).

2.3.9 Resource conservation – appliances

A study of consumer behaviour for a number of appliances found it difficult to identify insights that applied across difference classes of appliances (Young et al., 2010). Some appliance-specific studies have been designed by psychologists to examine user behaviour in response to technology attributes (rather than technology adoption). For example, a Dutch investigation found that integrating energy feedback into appliance design only led to reduced energy consumption if users were also provided with information to make sense of the feedback and had appropriate goals (McCalley et al., 2011).

Compact fluorescent light bulbs (CFLs) are a reasonably well investigated technology and CFLs have known benefits in terms of reducing energy consumption. A number of studies have looked for links between demographic data and the adoption of CFLs (for review see Mills and Schleich, 2010). An empirical survey of over 20,000 German households used an innovation diffusion framework to separate the factors that might affect a household's propensity to adopt, followed by the degree of adoption, i.e. how many CFLs were installed in the house (Mills and Schleich, 2010). While no factor of the household or its demography dominated the decision in either stage, the survey data did support this two-stage analysis.

For specific lighting practices in the UK, an exploratory study of 18 households in three urban areas recorded actual measurements, rather than perceived practices, complemented by in-depth interviews. This analysis found that while users were motivated to adopt energy efficient lighting for both environmental and financial reasons, this interest could be negated by a dislike of the visual appearance of the light bulbs or the type of light they cast. This means that practice (whether lighting in the home was used efficiently) was not solely dependent on cost considerations (Wall and Crosbie, 2009). Desirable appliance attributes vary in different cultural contexts and therefore in different places. In Norway, “hygge”, approximately translated as ‘cosiness’, is valued and displayed through a large number of low-glare, ‘warm’ lights whereas in Japan, clarity and brightness are valued, which facilitates the diffusion of CFLs with their white lights (Wilhite et al., 1996).

On another tack, a Dutch review of frameworks used to describe energy-conserving actions focussed mainly on firm-level actions but does include a study which emphasises the importance of installers in the adoption/non-adoption decision. It is reported that adopters of high efficiency boilers in the early 1990’s were well-informed and made a positive choice towards a (then) unconventional technology, whereas non-adopters were usually heeding an installer’s advice, where contractors were reluctant to install a less proven and more expensive technology (Dieperink et al., 2004).

2.3.10 Resource conservation – behavioural approaches

Focussing mainly on energy use, much literature has examined the possible scale of domestic resource conservation and the modes by which it can be accomplished. When looking at empirical studies providing data to inform this research, it is helpful to distinguish between resource conservation achieved through technology change and resource conservation accomplished through supporting behavioural change. This Section deals with behavioural change, while the following Section considers how investing in particular technologies might affect the efficiency of resource use.

Noting that analyses of household-level adoption of energy efficient technologies and practices are scarce, a 2012 investigation using survey data gathered in 2007 across 10 EU countries and Norway found that modelling user characteristics such as education level or demography could not explain the observed differences in behaviour between countries. The authors speculated on the macro-economic or building stock factors that might cause the between-country heterogeneity but did not have access to data to test this. A major omission from the dataset was household expenditure, making it impossible to consider the impact of energy costs compared to income or the impact of the possible benefits that the desired behaviours might bring (Mills and Schleich, 2012).

A 2005 review of 38 studies taking different approaches to encourage energy conservation in households included antecedent approaches (actions such as making a commitment or receiving information that might change the factors that shape intention and therefore behaviour) and consequent approaches (offering an outcome which is contingent on behaviour, such as real-time energy consumption monitoring). The authors had been prompted to consider the effectiveness of different approaches by the observation that despite an increasing interest in reducing household energy consumption since the oil-crisis of the early 1970s, household energy consumption continued to rise. Home audits were among the antecedent approaches (the type used in Case Study 1: RE:NEW, described in Section 4.1.1 below). The review found that of the antecedent approaches, supplying information alone raised awareness but did little to change behaviour. Several consequent approaches were more effective, including providing rewards and feedback, although results were not universally positive. The authors concluded that the underlying determinants of energy use and behaviour, or the longer term impacts of these approaches, had not been explored by psychologists at that point in time. They suggested two sets of factors at play: macro or "TEDIC" factors (Technological developments, Economic growth, Demography, Institutional factors, and Cultural development); and individual (user) factors (Abrahamse et al., 2005). This analysis provides a useful counterpoint to the conceptual framework developed in Section 3.3 below where factors are considered in terms of how they act at the level of the individual household (technology attributes), rather than in a wider context (technological developments).

Comparing the effectiveness of programmes designed to encourage efficient energy use in Sweden and in the UK found cultural differences (in Sweden, access to energy might be considered a citizen's right), technology differences, and institutional differences in the way in which generation and supply markets were structured all had a bearing on the final energy user's behaviour (Pyrko and Darby, 2009). An analysis of data from nine OECD countries failed to find consistent links between user attributes and energy saving in the home. The user attribute of "higher environmental concern" did appear to correlate with performing energy saving curtailment actions and with having some energy efficiency retrofits in the home, but environmental concerns had no statistical relation with major purchase actions such as buying energy efficient boilers or micro-renewables. Wealthier households had less environmental concern, but did invest in energy efficiency measures, suggesting perhaps that economic decision making takes precedence over environment-influenced decisions. In general, older people had a greater concern for the environment, but the reasons for this were not explored (Urban and Scasny, 2012).

Energy efficiency behaviours at the domestic scale have been examined by psychologists. One Dutch study suggested that energy use is determined by sociodemographic variables (principally household size and affluence) but energy saving actions are determined by personality variables. The personality variables relate to experience and attitude and are not described in place-specific ways (Abrahamse and Steg, 2009). A similar Danish study asked 312 comparable households in four neighbouring villages about their energy consumption behaviours and the energy-conserving actions they took, together with a battery of questions covering their household's goals and aspirations, perceived barriers, attitudes towards the environment and other measures which could be linked to elements of the TPB. Structural analysis of the results found linkages with strong echoes of expectancy-value models, although attitudes influenced personal norms which influenced action, rather than attitude linking strongly and directly to intention. This analysis also found that a household's degree of 'empowerment', perhaps an analogue for positive PBC, was critical in whether an action was taken (Thogersen and Gronhoj, 2010). A further Swedish investigation into the importance of environmental attitudes in shaping energy saving behaviours found that energy saving behaviours were much more closely linked to demographic variables (notably age and income) and housing tenure than to environmental attitudes (Martinsson et al., 2011).

Another Danish study explored the practice turn's implications for understanding energy consuming behaviours. The study examined the heating and cooling practices in households with identical homes supplied by the same district heating system and supplied with data comparing their energy consumption with their neighbours'. It found a variety of practices which could be linked to the household's interests (a desire to enjoy fresh air), beliefs (airing was necessary to maintain health) or previous experience (such as living in a larger house with much higher fuel bills) (Gram-Hanssen, 2010).

A further review of four case studies of different interventions to support energy conservation behaviour comes from the perspective of building design and occupancy rather than psychological investigation. The authors noted that evaluating the success of energy efficiency interventions is usually a technical exercise, with measurement and/or modelling of energy use before and after the intervention (Crosbie and Baker, 2010). However, this does not address why householders reject innovations that are economically viable, or why difficult or expensive interventions might be more popular with householders than relatively simple ones. New-build, eco-friendly houses had been purchased because they were in a desirable area, or because they would release more disposable income by reducing resource costs. Design and aesthetics were repeatedly noted as important to users. They conclude that promoting lifestyle benefits rather than environmental benefits, and ensuring that product design is user-friendly and aesthetically pleasing, are vital.

2.3.11 Energy efficiency investments

Empirical work examining consumer adoption of energy efficiency measures indicates that potential users treat the up-front, capital cost of an energy-related investment differently to possible financial savings from that investment, and concludes that individuals may not make the most economically effective choice (Gillingham et al., 2009). A survey of 3,000 Swedish home owners in 2008 confirmed that the main influence on the intention to adopt of energy saving measures was a desire to reduce bills, and that actual adoption was linked to a range of user and “contextual” factors, including the intrinsic qualities of the age of the building and the past investment it had received. This study also speculated that the regional variations in Sweden were based on the degree to which different municipalities had promoted energy efficiency (Nair et al., 2010) – an acquired place characteristic.

A mail survey of households in Nebraska, US, designed to investigate the constraints that prevented households undertaking energy efficient practices in the home found evidence to support social practice theory. It appeared that household behaviours were constrained by what was considered socially acceptable norms of comfort, cleanliness and convenience. This sample of 239 households were moderately concerned about the cost of energy, but not fundamentally unhappy with the energy efficiency of their home as it stood (Niemeyer, 2010).

Returning to examining the diffusion of energy efficiency investments amongst UK households, the desire to save energy, save money and have a warmer home were the three main motivations for adoption of products such as loft insulation, heating system controllers, condensing boilers or energy efficient lighting. Expense, and the (perceived) difficulty of installation (of the whole process e.g. clearing the loft as well as laying down insulation) were significant barriers to adoption and a range of product design improvements were suggested that would help to overcome such barriers (Caird and Roy, 2007).

A recent evaluation of the monetary savings and environmental benefits achieved through energy efficiency investment in UK households, using five years of data from the English House Condition Survey, found that dwelling type, tenure, age of household, income but also energy prices and the state of repair of the house, all affected the benefits achieved. The findings emphasise the need for a highly tailored approach, even within an area scheme where dwelling type, tenure or demography may not vary hugely (Tovar, 2012).

The diffusion of domestic energy efficiency measures have been scrutinised in the UK as they are a core element of the one of the UK Government's electricity supplier obligation policies, the Carbon Emissions Reduction Target (CERT) (DECC, 2011b)[2] which regulated how electricity suppliers had to support consumers in reducing their carbon emissions. A policy report identified seven types of barriers to the uptake of domestic energy efficiency measures including technology attributes such as capital cost and user attributes in terms of psychological/sociological barriers but also a range of institutional barriers such as:

- Hidden costs: many of these hidden costs are related to the cost of acquiring information about, for example, suppliers;
- Lack of information e.g. about level of energy expenditure, or how energy consumption can be reduced;
- Risks and uncertainty: uncertainty about future energy prices can deter households from investing;
- Poorly aligned incentives: such as the 'landlord-tenant' split where landlords may under-invest in energy efficiency measures because their tenants pay the energy bills; and
- Regulatory barriers (NERA Economic Consulting, 2007).

Energy efficiency measures that fall within the UK Supplier Obligation were also the subject of an investigation into how social networks supported or restricted technology adoption. This study found that up to one third of potential adopters prioritised information gained from speaking to someone they know above any external promotional campaigns and also found that the

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[2] CERT applied to the largest six electricity suppliers in the UK from October 2008 to Dec 2012, and was achieved through removing barriers to uptake of cost-effective energy efficiency measures such as insulation, heating and lighting, across all households

type of technology did change the response from potential adopters (McMichael and Shipworth, 2013).

2.3.12 Summary

Attempting to synthesise from the disparate studies reviewed in Section 2.2, Table 2.1 below presents a summary of the many factors which have been explored for their impact on the intention to adopt, the adoption and the use of domestic green technologies. These three stages reflect the stages of green technology adoption suggested by the innovation diffusion chain and the psychological models of behaviour reviewed in Section 2.1.2 and 2.1.3. Figure 3.1 below illustrates these three stages and they are used as a foundation to develop a conceptual framework as part of research design. In general, far more attention has been paid to the adoption of technologies than to the shaping of intention to adopt, or the actual use of technologies. Where the propensity to adopt or intention to adopt is explored, it is often through statistical analyses which suggest a correlation but cannot explain the reasons why such a correlation might exist.

Many studies were excluded from this review because they considered pro-environmental behaviour changes which were wider than the adoption of domestic green technology. Some crossover between discrete and on-going behaviour comes from the inclusion of technologies which aim to reduce resource consumption through supporting behavioural change. It is unsurprising that these studies provide the most commentary on the use of technology. There is overall, and again unsurprisingly, less exploration of more novel technologies such as heat pumps and modern biomass, as there are fewer datasets to draw upon.

It is also worth noting that local circumstances appear to provide motivation for particular research foci – whether that be the availability of energy assets (such as biomass in Scandinavia, sunshine in southern Europe or the southern states of the US) or resource pressures (such as water scarcity in Australia) – which suggests that the issue of place may offer more insights into the issues of technology adoption and use than simply topography and impact on technical feasibility.

The factors which have been researched are mainly technology attributes (notably cost and performance) and user attributes (demography and capacity), with the interplay between the two sometimes acknowledged, so that technology complexity is linked to the user capacity to understand that technology. In addition, regulatory and institutional factors and the supply chain or installer, are also mentioned in a smaller number of studies.

Table 2.1 Summary of empirical research study findings into the factors that affect the adoption and use of a range of domestic green technologies

	Factors affecting intention to adopt	**Factors affecting adoption or non-adoption**	**Factors affecting use**
2.2.1 Microgeneration – heat or electricity	Age (Willis et al 2010, Claudy et al., 2010)	Capital cost (Scarpa and Willis, 2010) Technology effectiveness; Regional supply chain maturity (Bergman and Jardine, 2009)	
2.2.2 Microgeneration – low carbon heat		Technology maturity; Compatibility (Roy et al, 2008, Caird and Roy, 2010) Technology performance (Mahapatra and Gustavsson, 2008)	Technology performance (comfort provided); Electricity price (Bjornstad, 2012)
2.2.3 Heat pumps			Understanding of technology; Fault-free running; Performance in space heating; Noise (Caird et al., 2012) Control systems (Boait et al., 2010)

	Factors affecting intention to adopt	Factors affecting adoption or non-adoption	Factors affecting use
2.2.4 Solar thermal	Technology attributes (perception of modernity) (Sidiras and Koukios, 2004) Solar radiation available (Mills and Schleich, 2009) Technical knowledge (Faiers and Neame, 2006)	Demography (age education, income, life stage); Technology attributes (product quality, product cost, product's social impact) (Labay and Kinnear, 1981) Interaction of demography and technology attributes in perception of risk associated with adoption (Guagnano, 1986) Technology attributes; Affluence of the area; Housing density (Zahran et al., 2008) Lack of direct financial benefit (Mills and Schleich, 2009)	Problems with performance (Sidiras and Koukios, 2004)
2.2.5 Biomass		Technology attribute – comfort provided (Nyrud et al., 2008) Understanding technology (Sopha and Klockner, 2011) Capital cost and subsidy (Sopha et al., 2011) Technology attributes including cost and installation; Household characteristics; Distance from fuel source (Kasanen and Lakshmanan, 1989) Capital cost; Commissioning; Pellet supply infrastructure (Roy et al., 2008)	Effort required for operation (Nyrud et al, 2008) Technology attributes – initial cost and technical performance (Skjeyrak and Sopha, 2012)

	Factors affecting intention to adopt	Factors affecting adoption or non-adoption	Factors affecting use
2.2.6 Microgen – renewable electricity	Potential adopter awareness of technology – which varied spatially (Claudy et al., 2010)		
2.2.7 Photovoltaic cells	Financial incentives; Individuals' motivations; Local context and history (Berger, 2001) Providing local information; User perceptions of complexity (Jager, 2006)	Individuals' motivations; Potential adopter's "experience and familiarity" (Kaplan, 1999) Financial incentives; Cost of electricity; Age (Kwan, 2012) Age; Income; Education; Tenure (Keirstead, 2007) Financial benefit (Cherrington et al., 2012) Previous energy conservation action (Haas et al, 1999)	
2.2.8 Water conservation	Perception of vulnerability to drought (Lam, 2006)	Experience of drought (Gilbertson et al., 2011) Experience of drought; Demographic factors (Fielding et al., 2012) Pro-environmental behaviour; Actively seeking information on water conservation (Dolnicar et al., 2012) Age; Education (Pinto et al., 2011)	

	Factors affecting intention to adopt	Factors affecting adoption or non-adoption	Factors affecting use
2.2.9 Resource conservation – appliances	Demographic factors (Mills and Schleich, 2010) Environmental benefits; Financial benefits (Wall and Crosbie, 2009)	Demographic factors (Mills and Schleich, 2010) Aesthetic appeal – for CFLs (Wall and Crosbie, 2009) Technology attributes / performance in relation to cultural preferences and norms (Wilhite et al., 1996) Installer's advice (Dieperink et al., 2004)	User motivation (goals); User capacity to interpret feedback (McCalley et al., 2011)
2.2.10 Resource conservation – behavioural approaches	User awareness of resource issues (Abrahamse et al., 2005) Attitudes; Personal norms (Thogersen and Gronhoj, 2010) Age; Income; Tenure (Martinsson et al, 2011)	Possibly building stock; Not demographic factors (Mills and Schleich, 2012) Household "empowerment" (Thogersen and Gronhoj, 2010) Lifestyle benefits; Aesthetic appeal (Crosbie and Baker, 2010)	Cultural norms; Technology availability; Institutions of energy generation and supply (Pyrko and Darby, 2009) Concern for the environment; Age; Economic benefits (Urban and Scasny, 2012) Personality variables (Abrahamse and Steg, 2009) Household interests; Beliefs; Previous experiences (Gram-Hanssen, 2010)

	Factors affecting intention to adopt	**Factors affecting adoption or non-adoption**	**Factors affecting use**
2.1.11 Energy efficiency investments	Financial benefit (Nair et al., 2010)	Capital costs (not whole life costs) (Gillingham et al., 2009) User characteristics; Age and history of building; Regional authorities' attempts at promotion (Nair et al., 2010) Social norms of comfort, cleanliness and convenience (Niemeyer, 2010) Financial benefit; Capital cost; Disruptiveness of installation (Caird and Roy, 2007) Dwelling type, condition of repair and tenure; Age and income of household; Energy prices (Tovar, 2012) User characteristics; Technology cost; Institutional and regulatory barriers (NERA, 2007)	

2.4 The research questions

Surveying these various literatures revealed apparent gaps in existing reported knowledge. Recognising these gaps, and moving from the broad area of research interest: **the adoption, use and impact of domestic green technology**, three more specific research area arise. The gaps are:

- the interaction of technology attributes and user attributes, particularly in the context of area-based schemes;
- the factors that affect actual impact of domestic green technology in use post-adoption compared with intended or designed impact; and
- how 'place' affects domestic green technology diffusion and subsequent impact.

The first gap identified from the review of literature in this chapter is a nuanced understanding of **the interaction of technology attributes and user attributes, particularly in the context of area-based schemes,** which may offer ways to change user attributes (such as capacity) or the social norms in an area. Although how the particular attributes of domestic green technology affect the adoption decision making of individual potential adopters has been evaluated, and the effect of user characteristics on area-based approaches to reducing domestic resource demand has also been examined, these two areas of enquiry have rarely been linked. For domestic green technology, the relative advantage provided by the technology differs between household and institutional or societal levels. Society primarily wants a reduction in resource use or resource demand (although this may not be a solely-specified aim), and area-based schemes may tend to reflect those societal goals. At the individual and household level, the desired relative advantage is more complex. The individual or household still wants the service provided by the technology (warmth or light, for example) but in a way that is affordable, and fits with the household's norms.

Modelling that looks at impacts in urban systems has rarely been technology-specific. The term 'urban metabolism' was coined in the 1960s to describe urban systems as organisms through which materials flow, being processed and transformed along the way (Wolman, 1965). As a review article has explored, the many studies of urban metabolism tend to focus on how the transformation of materials can be modelled rather than being empirical observations of how efficiently resources are used (Barles, 2010). The focus on modelling methods such as material flow analysis and energy balances mean that assumptions are made about technology performance, and these assumptions are rarely tested or compared with real outcomes.

This leads to the following research question:

Q1: What factors affect the adoption of domestic green technology as promoted in area-based schemes and how does the impact of these factors vary throughout the technology adoption decision making process?

The second gap in apparent knowledge identified from the review above is in identifying the factors that affect the actual impact of domestic green technology in use post-adoption compared with its intended or designed impact.

While the mechanisms of technology or innovation adoption are well reported, the link between adoption and use or impact is not explored as comprehensively. In the current era where governments in developed economies are promoting technology adoption to counter the impacts of climate change, understanding the real impact in use is an important part of knowledge gathering to support further policy development. UK policy targets are the amount of installed capacity for microgeneration and for economy-wide levels of emissions, rather than the per capita consumption of (renewable) energy. Studies often stop at the point of technology adoption, in part, no doubt, because measuring the number of installations is certainly easier than measuring the impact of installations. The exception, as illustrated by Table 2.1, is where the purpose of the technologies is to change behaviour in some way, in which case research focuses on use. Studies have monitored consumption behaviours for households with a technology configuration already in place (Owen, 2012) and have examined how households respond to new stimuli within that existing configuration, such as feedback or smart meters (Hargreaves et al., 2010, Brandon and Lewis, 1999, Grønhøj and Thøgersen, 2011). Few, if any, have monitored consumption behaviours before and after the adoption of domestic green technology. A further complication is that the number of technology installations and the impact of those installations are not linearly related. Performance of individual installations will vary, in part due to the indirect effects such as the rebound effect outlined in Section 1.5.4, but also due to the particular configuration of the installation and the needs and capacities of its users. Understanding how these factors, including the technology, location and users, affect technology performance and impact would help in the design and implementation of holistic schemes which were effective in reducing resource consumption. This leads to the second research question:

Q2: What factors shape the use, and therefore impact, of domestic green technology contributing to differences between intended (designed) impacts to reduce resource use and the actual impacts on resource use?

The third gap in reported knowledge is identified as how 'place' affects domestic green technology diffusion and subsequent impact. Spatial modelling of innovation diffusion has been carried out for innovations as diverse as cars, cable television and new maize hybrids (Rogers, 2003). But how many televisions, or smart meters, or tap restrictors are in a given population, or even where they are, does not tell us what the impact on resource use of those technologies will be. Diffusion models are also often aspatial. A paper which considered agent-based modelling in ecological economics found that modelling is generally more effective in describing socio-ecological complex systems than in explaining the behaviour of such systems. The authors note a high volume of use of agent-based modelling in exploring economic and technological choices in urban environments (Heckbert et al., 2010). Understanding individuals' behaviour is a knowledge gap which needs to be filled if such models are to become more useful in assessing the potential outcomes of technology policy.

Some research into the adoption of green technology recognises that there is spatial variation in adoption rates and sometimes speculates on the causes of this variation (e.g. Mills and Schleich, 2012, Nair et al., 2010). However, the potential reasons for this have not been considered systematically across different technologies. The way in which place characteristics affect user characteristics and then affect behaviour has been explored, although this has tended to be in the context of general pro-environmental behaviours (e.g. Scannell and Gifford, 2010) rather than in the specific case of green technology adoption.

Recognising that one of the motivating observations for this research was that similar schemes appear to achieve different outcomes in different places, there seems to be a need for a nuanced rather than statistical understanding of why spatial variations occur. What are the mechanisms that shape this variation? This leads to the third research question:

Q3: What is the role of 'place' in the adoption and use of domestic green technology?

Section 2.1 reviewed literatures including innovation diffusion, aspects of environmental psychology, social practice and neighbourhood effects in order to uncover the types of factors that might affect the adoption, use and impact of domestic green technology. The empirical studies of domestic green technology adoption reviewed in Section 2.2 confirm that while these factors may play a role, they have not been explored systematically across the range of technologies which might reduce domestic resource consumption. Specifically, while user attributes and technology attributes are well researched, examining the role of place in affecting domestic green technology adoption appears to be novel. Chapter 3 develops an approach and then a research method to address the research questions identified.

Chapter 3 Research Design

3.1 Research questions

Within the broad research agenda of "What affects the adoption, use and impact of domestic green technology?" three distinct research questions to inform the development of a conceptual framework emerge from the literature review:

- What factors affect the adoption of domestic green technology as promoted in area-based schemes and how does the impact of these factors vary throughout the technology adoption decision making process?
- What factors shape the use, and therefore impact, of domestic green technology contributing to differences between intended (designed) impacts to reduce resource use and the actual impacts on resource use?
- What is the role of 'place' in the adoption and use of domestic green technology?

These are more focussed than exploratory research questions seeking to understand a new phenomenon, but they are not as tightly defined as wholly confirmatory research questions seeking to test a hypothesis. Exploratory research questions are used to understand new phenomena. The continuum of research questions from exploratory to confirmatory runs roughly parallel to a continuum of research designs, from unstructured to structured research methods. The research design for these questions needs to have some structure but allow for flexibility by using a conceptual framework and then exploring what happens within that framework.

3.2 Research philosophy and strategy

While the purpose of this research has been to add to the theoretical body of knowledge, it has been motivated by observations that arise from the researcher's experience of real world projects. It is perhaps therefore unsurprising that the philosophy which dominates the research strategy and design is **pragmatism**. This is not in the general linguistic use of the word – a concern for practical matters – although that is appealing. Rather, pragmatism here refers to a philosophical position which seeks a middle ground between dogma and scepticism and which co-prioritises the natural and physical world with the emergent and social or psychological world (Robson, 2011 p28, Burke Johnson and Onwuegbuzie, 2004, Cherryholmes, 1992). Pragmatism as a research philosophy has received attention in the development of mixed methods, where qualitative and quantitative data from a variety of sources, gathered through different methods, are all brought to bear on an enquiry (Feilzer, 2010). A pragmatic approach allows for a new theory to be advanced on the basis of existing theory, but enables that suggestion to be developed in light of a range of evidence describing physical and social phenomena. In this case, a conceptual framework has been developed by synthesising elements of theoretical positions from several areas. That framework provides the basis for enquiry, but is updated and further developed as phenomenological data, descriptions of the lived experience, are gathered and analysed. An essential element of the pragmatic research philosophy is an interest in the consequence of asking and answering research questions (Mertens, 2012, Cherryholmes, 1994) and because of this, the researcher's own values and interests are part of the method rather than designed out in the search for positivist 'truth' (Cherryholmes, 1992).

Investigating the research questions arising from the gaps in the literature demanded mixed methods. Gathering data which reflects why and how people consider, adopt and use domestic green technology generates qualitative data using an ideographic approach, trying to create a rich picture of effects and their context. This is contrasted with a nomothetic approach for which gathering quantitative data describing the levels of adoption and spatial patterns of adoption would be more appropriate. In order to get beneath the skin of observed phenomena, such as the reported levels of technology adoption, qualitative data collection allows for a more nuanced understanding of why these patterns occur, what the motivations, interests and experiences of individuals are, how consistent these are, and how context dependent. However, by gathering data from multiple sub cases within five contrasting cases, the approach taken does have some nomothetic features and might be considered a type of mixed methods approach. As with any method, analysing the data cannot prove causality. Rather, the approach taken allows for explanatory questions of "how" and "why" to be explored (Mason, 2002, Mostyn, 1985), which is congruent with how the research questions are framed.

Previous UK research (described in Section 2.2) has used quantitative methods to establish patterns and correlations between demographic factors and domestic green technology uptake and use (Caird et al., 2008, Roy et al., 2008, Caird and Roy, 2007), supplementing these larger datasets with self-reported data from adopters and non-adopters. A large postal or email initial survey was considered for this research in order to generate a bigger, albeit less rich, dataset than interviews could provide. In assessing the data that might be generated by such an initial survey, it was concluded that this would not help significantly in focussing a second stage of interviews in such a way that meaningful answers to the research questions could be obtained. Another study which considered the adoption of heat pumps and biomass stoves, and evaluated the Norwegian subsidy programme for low carbon heat in 2003, noted that one of the problems with the study design of using a questionnaire to gather data which could be statistically analysed, was that this form of data offered no insights into what might trigger a behaviour (Bjørnstad, 2012), reinforcing the need for this research design to go beyond questionnaires.

Instead, a **case study approach** has been used to frame individual responses in a shared context. Additionally, the empirical studies reviewed in Section 2.2 have already identified a range of factors which could be used in the conceptual framework. It was judged that the insights from a smaller sample of households within selected case studies or area-based schemes should be accessed directly. A case study approach is defined as "an empirical inquiry that investigates a contemporary phenomenon in depth and within its real-life context" (Yin, 2009 p18). In particular, where there may be more variables of interest than data points, the "benefits from the prior development of a theoretical proposition to guide data collection and analysis" can shape case study design. This reinforces what a pragmatic approach suggests: the need to develop a conceptual framework before data collection and analysis.

Given the interest in place and location, it was desirable to collect multiple datasets with a common 'place' context. This research takes the area-based scheme as the unit of the analysis. There are, of course, many cases where households adopt green technology and are not part of area-based schemes. Data was collected from three such households who are 'innovators', with the intention of using their views to inform and shape both the data collection and analysis of the five area-based cases. Some justification for the area-based scheme as the unit of analysis is therefore helpful. An assumption was made that an area-based scheme would provide the context for a greater rate of adoption than elsewhere and would offer more experiences (of adoption, and non-adoption) to investigate. The case has been made in energy policy literature that a focus on the local will be much more technically effective than big centralised projects thus recognising that renewable energy, in particular, is very sensitive to local conditions in terms of its impact and the costs and benefits it holds in a particular area (Jefferson, 2008). It seems appropriate to enquire as to how such locally differentiated approaches function in practice.

Households (both adopters and non-adopters) are sub-units of analysis (Yin, 2009) and further data is provided by others who offer different perspectives (installers and facilitators). In developing the case studies, most original data were collected through interviews, with additional information from the grey literature of technical reports and press articles.

There are different types of case study. The conception of 'case' which underpins this research is a realist one. That is, the cases (the area-based schemes) and sub-cases (households) exist as empirical units, rather than a nominalist approach which would identify cases as theoretical constructs. Further, the area-based schemes to support green technology adoption are a general, rather than a specific type of case, such as peri-urban technologies to reduce carbon impact, and the approach taken is one of "cases as objects" (Ragin and Becker, 1992). These cases, the area-based schemes, do exist. The research does not seek to verify that they exist or are defined by particular empirical boundaries because "area-based scheme" is a convention which does not require creation of a detailed explanatory definition.

A conceptual framework is developed (in Section 3.3 below) to provide a way of organising and understanding case study data, and the research method was designed to gather data that would explore the degree to which people described their own behaviours in ways that fitted the framework. In this regard the research was positivist, seeking to gather data to test the conceptual framework, a form of hypothesis. In case study work, there is a tension between structure, which will enable data to be collected and compared between cases, and flexibility to allow the researcher to be responsive to the data that is uncovered in each case, triangulating data as she continues (Smith and Robbins, 1982).

The conceptual framework still leaves open the question of to what degree the different attributes might hold influence at different stages, a more post-positivist form of enquiry. It has been suggested that the need to hold elements of these two approaches, positivist and post-postivist, is not unusual in case studies (Vaughan, 2005). In the context of water demand management, the difference between data gathering, with the rigour essential to the positivist tradition, and accessing data, prioritised by the post-positivists, has been described (Sharp, 2006). The challenges involved in working across these different theoretical approaches have been recognised (Sharp et al., 2011). While this research sits most comfortably within the framework of positivist investigations, it is informed by post-positivist work in socio-technical systems and user practices (Robson, 2011 p22).

An alternative approach would have been to focus on only one case study, or one technology, and gain a deeper understanding of that case. However, part of the research purpose was to seek to understand whether a broad conceptual framework might apply across different technologies, and how the emphasis within the conceptual model varied with technology type. By collecting data from a variety of sources and cases, there is the opportunity to identify factors which appear unimportant in one case but are decisive in another. However, care is needed not to fall prey to a kind of 'ecological fallacy'. Although the term 'ecological fallacy' is usually applied to interpreting statistical data incorrectly and in such a way that average values for an individual are taken to represent average values for the group to which that individual belongs, the risk with this data is that one individual adopter's decision making process is taken to reflect the experiences of all adopters. This risk is avoided by applying appropriate caveats and qualifications to the results obtained from analysing the data and ensuring that there is no extrapolation of results outside those parameters, for example, not suggesting that the experience of an adopter in an area-based scheme is taken to represent the experience of an adopter outwith any such scheme.

3.3 A conceptual framework for the adoption and use of green technology

Drawing on Sections 2.2.2, 2.2.3, 2.2.4 and 2.2.5 (innovation diffusion theory, environmental psychology, practice theory and neighbourhood effects theory), a conceptual framework has been developed which combines aspects of existing theory to be used as a basis for exploring the adoption and use of domestic green technology and for organising case study data to answer the research questions.

Both innovation diffusion theory and the psychological models of behaviour suggest that the decision to adopt is a staged process. Three stages, illustrated in Figure 3.1, lie at the core of the conceptual framework used by this research: intention, adoption, and use. Intention combines “knowledge” and “persuasion” in the model of innovation diffusion. Adoption is analogous with “decision”. Use combines both “implementation” and “confirmation”.

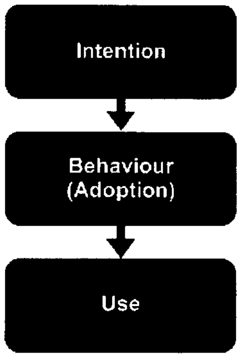

Figure 3.1 Three stages that form the ‘spine’ of the conceptual framework

Innovation diffusion frameworks tend to halt at the point of adoption, even though subsequent behaviour, such as reinvention, or discontinuance, is acknowledged as critical to the impact of innovation adoption (Rogers, 2003, p180). The conceptual framework developed here does not stop at the point at which a technology is adopted by a household but extends into ‘use’. The technology may be trialled for a while and then discontinued. Discontinuance has been divided, for production systems in firms rather than consumer products in households, into ‘replacement’ ‘or disenchantment’ (Abraham and Hayward, 1984). If it is adopted, the nature of the innovation’s impact may change over time as household practices change and as the household’s learning about their resource systems change. This part of the model reflects one of the themes in the current understanding of behavioural change and energy use, “technical infrastructures and social norms interact to affect behaviour over time. Both may be resistant to change” (Owens and Driffill, 2008 p4414).

The difference between intention and action, termed the ‘value-action gap’, the gap between what people state is important to them and how their actual behaviours fit those priorities, has been examined in many areas. There is a value-action gap between stated knowledge or beliefs and behaviours in a number of green technology areas, including recently hydrogen energy (Flynn et al., 2009) and acceptance of wind farms (Toke et al., 2008), but the causes of this gap are not easily reduced to a lack of information, or motivation, which are the main interests of the environmental psychologist. The value-action gap of communities in Cambridgeshire has also been studied, partly to see whether cues that existed in locations might narrow the gap (Fleiter et al., 2011). In this case, information provision and support for action from the local authority did seem to make a temporary improvement. Work on the adoption of energy efficient lighting in the UK has highlighted the size of the value-action gap, with even those professing themselves to be "green" still reluctant to switch lighting (Wall and Crosbie, 2009). However, the nature of the value-action gap will vary depending on the attributes of the technology which supports the desired behaviour. It may be that the use of technology, which leads to the impact on resource use in the home, may be more habitual than cognitive. Thus one set of factors will shape the intention to adopt, but another will shape adoption and use.

Once the 'spine' of three stages is established, then the framework needs to provide some way of organising the factors which might play a role in influencing the three stages, and this scheme of organising factors needs to allow for the research questions to be explored. The research questions require that technology attributes and place attributes are distinguished. The factors that are identified by the expectancy-value model of behaviour highlight the role of the individual or user and this provides a third broad category of factors to look for: user attributes. Figure 3.2 illustrates the conceptual framework.

Each of the sets of attributes that shape the chain of activity towards technology adoption and use is sub-divided into categories drawn from the literature described in section 2.2 above. These categories are:

- Technology attributes: relative advantage, compatibility, complexity, observability and trialability.
- User attributes: attitude towards technology adoption, social norms, perceived behavioural control
- Place attributes: intrinsic characteristics, acquired characteristics, sociodemographic characteristics.

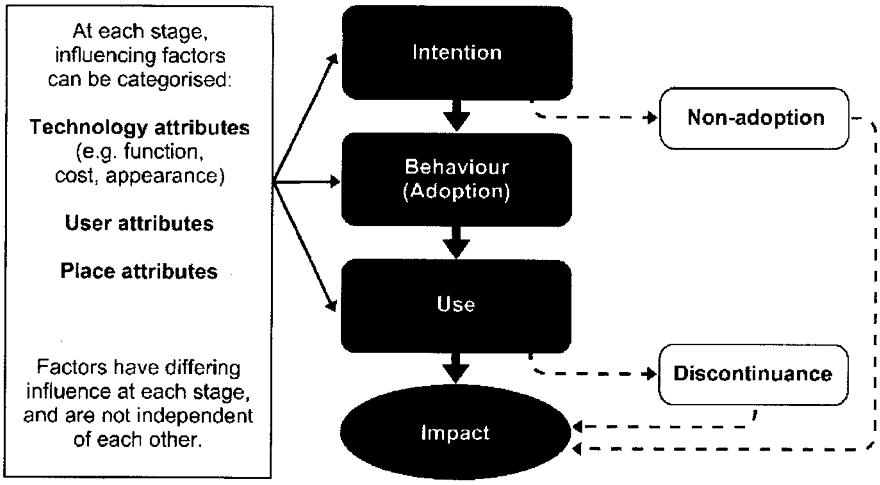

Figure 3.2 Initial conceptual framework

Returning to innovation diffusion theory, the innovation decision chain suggests that user and place characteristics (such as demography) are most influential at the initial "knowledge" stage, while technology attributes are critical to the second "persuasion" stage. The conceptual framework developed here does not assume this. Rather, the question is asked as to whether and how the technology, user and place attributes affect each of the three stages, including implementation/use, in order to vary the nature of the outcome of technology adoption. Thus the conceptual framework goes beyond Rogers' investigations of why and how an adoption decision is made, to what the impact of that technology in use might be.

A further point to note in this conceptual framework is that the arrows from the attributes to the stages of decision making and action are uni-directional. The research is investigating the influencing of attributes on behaviour, not of behaviour on the perceptions of attributes, although such influences can be imagined. For example, a high volume of positive adoption decisions in a neighbourhood might make photovoltaic cells more visible and change the cultural norm in a location. Recognising the dynamic nature of relationships between attributes and behaviour is beyond the scope of the proposed model, an issue which is recognised in Section 5.3 when limitations are discussed.

3.4 Case study selection

Case studies of area-based schemes were selected purposefully to cover a range of technologies (listed and briefly described in Appendix 1). Purposeful selection allows for selection of information-rich cases from which a great deal can be learnt (Coyne, 1997). Purposive sampling is an iterative process as data is collected and it becomes clearer which areas need to be explored in order to respond to the research questions (Mason, 2002 p95). Case studies were selected partly to offer comparisons of different geographical contexts but mainly to provide comparisons of technologies at different stages in terms of their maturity and adoption in the UK. The Challenging Lock-in through Urban Energy Systems (CLUES) project identified 182 area-based energy schemes targeting existing buildings in the UK in 2011 and 160 of these included promoting technology, although technology deployment was rarely the sole objective. These 160 schemes encompassed microgeneration deployment, energy demand management measures and, frequently, both approaches to changing energy systems (CLUES, 2011). A separate project compiling the reports of only those UK schemes which were led by community groups rather than the public sector identified 113 case studies (Hargreaves, 2011b).

The five case studies selected here cover all types of schemes promoted in the UK, excluding action by individual households and action led by the private sector. Deliberately selecting cases of difference can allow what is common to be seen more clearly (Vaughan, 2005). This selection was made on the assumption that it would help identify how the impact of the attributes of interest (users, technology, place attributes) might change as technology becomes more widespread. The most mature technologies are the energy conservation 'easy measures' installed by advisers in the London RE:NEW programme. For these technologies (e.g. insulation, draft proofing, smart metering, low energy light bulbs), the function of the technology is well understood, but the technology's performance and outcome can depend upon user behaviour and preferences. Transition Streets Totnes provided funding support for PV installations after households had been through a process of peer learning about energy issues. Kirklees' RECharge provided interest-free loans for a wide range of microgeneration technologies. The introduction of the Feed-in Tariff during RECharge, and just at the outset of Transition Streets Totnes, changed the motivation for electricity microgeneration adoption and the rapid adoption of PV in particular led to PV being considered a much more familiar and mature technology at the end of the case study period than at the beginning. The air source heat pumps which were the technology focus of the East Riding Yorkshire Affordable Warmth programme remain an unusual technology for domestic retrofit. A small group of innovators deploying novel technologies were also interviewed in order to provide comparison data without constructing a full case study.

A potential weakness of selecting case studies with different technologies was that comparisons might have been difficult, but it was decided that this was acceptable in light of the opportunity to compare technologies at different stages of maturity and different levels of diffusion, which might therefore be considered to be more or less suitable for different types of users. Figure 3.3 illustrates how the case studies varied with the stage of technology diffusion and Figure 3.4 provides some illustration of the geographical spread of the case studies. Sections 4.1.1-4.1.5 provide fuller descriptions of each case.

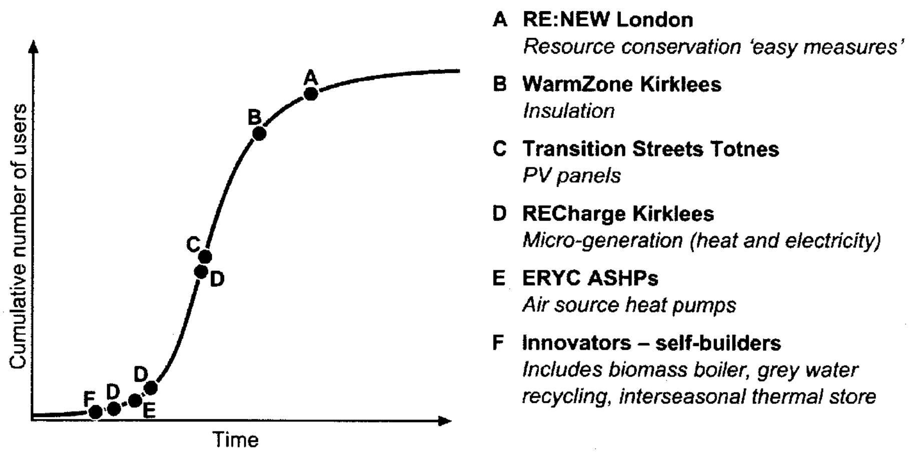

Figure 3.3 Case study technologies on a diffusion curve

Another factor which influenced case study selection was the accessibility of data. In three cases (Totnes, Kirklees RECharge, Kirklees WarmZone) the author's personal contacts provided a way in to find participants. These initial contacts also led to recommendations for further case studies (East Riding and RE:NEW), with the contacts providing some legitimacy for the author when establishing a connection with these latter schemes. Accessibility of data is important. In Kirklees WarmZone, it proved impossible to reach non-adopters. The scheme managers had also failed to reach these people, despite having made six attempts through different modes (doorstep, phone and email) at different times of day over a period of three years, and the WarmZone case study consequently lacks some of the richness of the others where the non-adopter perspective brings new information.

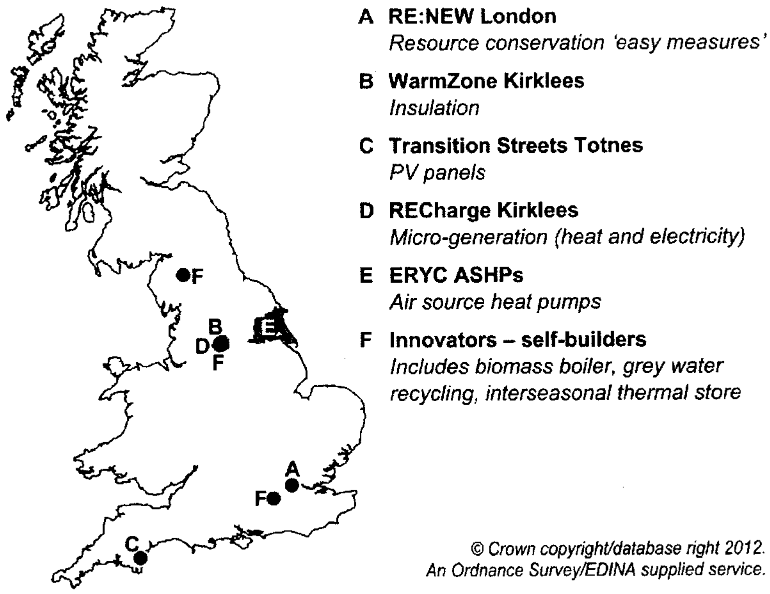

Figure 3.4 Case study location

Within case studies, interviewees were then identified. Four different roles were defined within each case study that would provide different perspectives on the interplay of the various factors in the model. The research design intended to gather views from across these roles in the five different case study area-based schemes. The intention was to interview individuals who were:

- Programme managers and facilitators – one form of "change agent" (Rogers, 2003, pp365-401);
- Surveyors and installers – another form of change agent;
- Adopters; and
- Non-adopters – individuals who had considered technology (i.e. individuals who had been through the "intention to adopt" stage) but had not proceeded[3].

[3] Those who have never considered the technology are another group of non-adopters. This group was not sampled for two reasons. Firstly, the interview protocol centred on the experience of green technology and interviewing this set of non-adopters would not have been able to start from that position. Any data that could be elicited would only shed light on how the 'intention to adopt' stage was formed, not the adoption stage. Secondly, there was also the practical consideration of identifying and

The two latter roles reflect the scale of the sub-cases; answering the research questions required a particular focus on the decision making at household level. Adopters or non-adopters were asked about their personal experience as part of their household. The emphasis on household, rather than area (macro) or individual (micro), reflects an interest in what has been suggested to be a rather neglected meso scale (Reid et al., 2010). However, the data gathered represents individual user perspectives, although it may comment on the behaviour of others in the household or the total impact of all those in the household through, for example, the size of energy bills. Data was collected from single individuals in adopting or non-adopting households in all but two sub-cases (one in Totnes, one in REcharge) and two innovator households. For these four households, the transcripts record input from two members of the household.

Recruitment varied between the case studies. Interviewees were also selected purposefully for the cases investigated first. In the early stages, initial interviewees may be chosen because of their knowledge, allowing the lines of enquiry to develop as sampling leads to the less expert. Two groups of individuals helped in this way; initially the five contacts in the pilot investigation (see Section 3.6 below), and latterly the small group of eco-build innovators. For REcharge, WarmZone, and ERYC, the local authority's agent provided contact details and checked that individuals were willing to be interviewed. In Totnes, a snowball technique was used to capitalise on personal contacts in one particular 'Transition Street' and to reach as many households as possible in that street of 25 similar terraced properties. The small number of innovators was gathered through an article in *Green Building* soliciting participants (the full article is at Appendix 3.A). The summary of 54 interviewees (providing 62 datasets) completed is provided in Table 3.1. The relatively small sample size of each role or sub-case within the five cases was a result of the data generated, in that interviews continued until there appeared to be no further variation in the accounts that individuals gave of their experiences, suggesting that the majority of views had been collected. Four participants provided both an interview and fieldnotes from a site visit (e.g. the RE:NEW advisers). Three interviewees were interviewed twice

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accessing participants who were in this category. They were, by definition, not amongst the lists of contacts held by the case study managers and different forms of recruitment would have been required.

because they were in the pilot cohort or first contacted early in the investigation and an update on their experience was sought to yield additional data. One other interviewee also volunteered the transcript of an earlier interview he had undertaken for a related research project.

Table 3.1 Summary of interviews

	Programme Managers	**Installers / Surveyors**	**Adopters**	**Non-adopters**	**Case total**
RE:NEW London	4	2	2	-	8
WarmZone Kirklees	2	1	-	-	3
Transition Streets Totnes	1	1	6	4	12
REcharge Kirklees	2	2	8	5	17
ERYC ASHPs	3	2	6	-	11
Innovators	-	-	3	-	3
Total	12	8	25	9	54

3.5 Interview design

The research method had some degree of structure, suggested by the conceptual model, but the interview process of data collection also needed to allow for new factors unforeseen by the model to emerge. Views were collected through semi-structured interviews following an outline interview guide but allowing for conversations to follow avenues of particular interest to the interviewee. The guide provided a prompt sheet for the interviewer and a way of ensuring that casebook data was gathered (see Section 3.9 below for further discussion of casebook data), but it did not provide a mechanistic manual for the interviews. Effective data collection through semi-structured interviews requires considerable skill in empathy, framing open questions, avoiding leading or closed questions and probing for information beyond an interviewee's first, sometimes hesitant, response (Merton et al., 1990).

After an introduction and discussion of consent, interviews usually started with a request to the interviewee to describe the process of participating in the scheme as they had experienced it. Encouraging the interviewee to tell the story of their involvement was followed by asking them to say more about their perceptions of the area where they lived. This was intended to gather data which could help with analysis about the role that place characteristics might play in the adoption and use of green technology. Finally, a series of factual and closed questions allowed the interviewee's dataset to be categorised. By placing these questions at the end of the interview once a rapport had been established, the interviewee appeared to be more comfortable with answering questions which may otherwise have been considered intrusive, about age, occupation and intentions to remain in the area. An interview typically lasted between 30 minutes and an hour. Telephone interviews tended to be shorter than face-to-face interviews, in part reflecting the different rapport that is established when meeting someone in person, and also reflecting the logistics of meeting someone, the cup of tea to be consumed and time that it is possible to spend in setting up. The full interview guide is attached at Appendix 3.B.

3.6 Pilot

A small pilot study was undertaken (four interviews from five potential participants approached) to test whether data collection through interviews followed by template analysis (described in more detail in Section 3.9 below) would generate useful insights. The pilot study also provided the opportunity to test the conceptual framework and develop the researcher's own skills in interviewing, data collection and analysis. The context of these interviews and the learning about process and method then applied to the full research design is summarised in Table 3.2.

Table 3.2 Pilot investigation summary

Area-based scheme	**Interviewee role**	**Timing and format**	**Learning (for researcher)**
Transition Streets Totnes	Adopter	Face-to-face interview in home surroundings. Approx. 1 hour.	Tailoring interview guide and style to level of knowledge of interviewee. Practicalities of transcription.
WarmZone Kirklees	Installer	Face-to-face in interviewee's workplace. Approx. 1 hour.	Practicalities of audio recording in different locations.
WarmZone Kirklees	Programme manager	Telephone interview.	Use of field notes instead of full transcript.
WarmZone Kirklees	Programme manager	Telephone interview.	Ensuring conversations cover interview guide when interviewee has a range of

Area-based scheme	Interviewee role	Timing and format	Learning (for researcher)
			well-rehearsed thoughts.
REChargeKirklees	Adopter	Two phone conversations leading to interviewee refusing full interview.	How to contact busy interviewees. How to explain research and what information to provide in order to have opportunity for a full conversation. Role of field notes to supplement transcript.
REChargeKirklees	Non-adopter	Phone interview. Approx. 35 minutes.	Background information to be provided. Need to frame "place based" aspects of the interview guide in a more direct form. How to allow interviewee to say what they want to say, while also ensuring that interview covers areas of interest.

These pilot interviews provided the opportunity to test the appropriateness of the research method, and to refine the practicalities of the processes that the research method required.

After the pilot, the sampling strategy and approach was adjusted, the interview guide was adapted and a full participant information sheet was developed. The most significant adjustment came in recognising the potential influence of installers and the installation process. "Installers" was added as a category of factors that might influence intention, adoption and use, as illustrated in Figure 3.5.

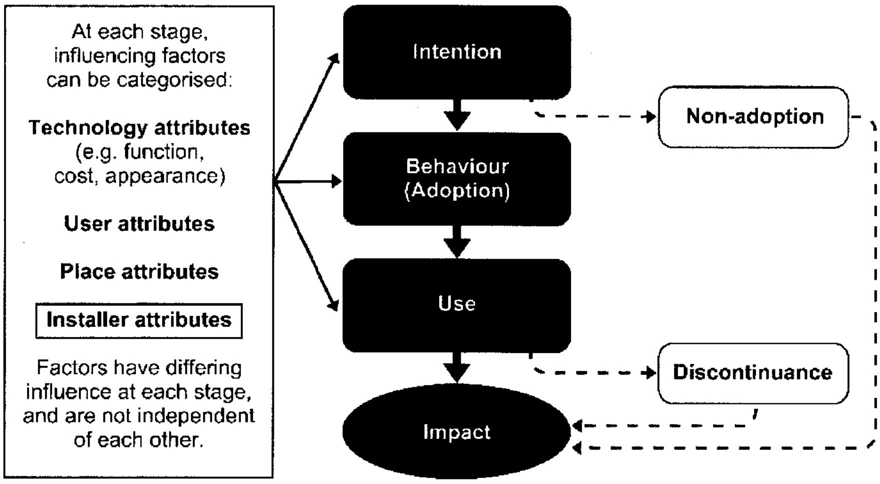

Figure 3.5 Conceptual framework after pilot investigation (Owen et al., 2012)

3.7 Data collection

The method, approach to confidentiality and papers to support informed consent were all submitted to the appropriate University of Leeds Ethics Committee for approval prior to the first full set of interviews in Kirklees. A supplementary submission to the same Ethics Committee was made before the Totnes interviews were carried out because of the different method of participant recruitment (snowball method rather than sampling). An example of the information sheet and participant consent form, and the letter from the Ethics Committee approving ethics of proposed approaches are attached at Appendix 3.C.

Pilot interviews took place in October 2010 and timing of the remaining interviews is also summarised in Table 3.3. The season of the year when data collection was carried out is worth noting. Heating or heat conservation technologies may be more visible to users and potential users during cold weather. The ASHP interviews took place mainly as winter approached for users, although they had strong recollections of the previous two very cold winters, and in some cases apprehensions about the coming season. Most PV adopters were interviewed in the summer when PV panels were producing the highest levels of electricity from incident sunlight that they can. An example of how the timing of data collection might affect results is provided in a Swiss study looking at consumer behaviours affecting energy conservation. It noted that carrying out data collection during mid-winter when heating demand is high could lead to participants overestimating their general energy consumption (Sutterlin et al., 2011).

Table 3.3 Summary of interview timings and mode

Area and scheme	**Method of participant recruitment**	**Interview timing**	**Mode**
RE:NEW London	Contacts provided by GLA	April-May 2011	Face-to-face and participant observation
WarmZone Kirklees	Contacts provided by local authority	April 2011	Phone and face-to-face
Transition Streets Totnes	Snowball	July 2011	Face-to-face
RECharge Kirklees	Contacts provided by local authority	March-June 2011	Mostly phone
ERYC ASHPs	Contacts provided by local authority in collaboration with other research	October-November 2011	Face-to-face
Innovators	Volunteered via *Green Building* or personal networks.	April-June 2011	Phone and face-to-face (home visits)

There is also variation in the timing of data collection within the overall schemes. Some data collection was carried out after scheme completion and some took place while schemes were in progress, although in all cases the scheme was 'live' for the scheme managers because delivery, completion or evaluation was still ongoing and in London, East Riding and Totnes further funding options were being developed to continue similar work. This is summarised in Figure 4.2.2 in Section 4.2 Cross-case analysis. It is worth noting that the data collection for RE:NEW took place before funding was approved for the full scheme. Data was collected from individuals who had been part of the pilot scheme which led to full RE:NEW funding, and the adviser visits attended and adopters interviewed were part of the RE:NEW process being continued by the managing agents while full funding was awaited.

There was some variability in the context of the data collection. All interviews and observations were carried out by the same interviewer using the same protocol but some interviews were by phone and other face-to-face. The time of day varied with interviews and visits during the day or outside normal working hours, depending on the interviewee's availability and preference. Adopters and non-adopters were interviewed while in their homes. Facilitators and installers were interviewed in their workplace. This reflected the location where the participant was most likely to be 'in role' with the perspective on their experience of the scheme which was most relevant to the enquiry. All interviewees selected a time for the conversation that suited their other commitments and availability, helping ensure a positive engagement with the interview. The main interviewer was accompanied by two more experienced researchers for three of the interviews in the East Riding case study (with only two researchers in total present at any one interview). In addition to the 62 interview transcripts and fieldnotes, from visits with 54 individuals, data was also gathered from other sources, notably reports and scheme evaluations.

3.8 Transcription

All interviews where permission to record was formally obtained were fully transcribed by the interviewer. A small number of these conversations were supplemented by field notes (n=5). Another set of data sources (n=10) were field notes from conversations where permission to use views in the research had been obtained, but there was not formal consent to full recording[4]. An example of a transcript is provided at Appendix 3.D. The transcripts were not phonetically accurate and a decision was made not to attempt to replicate accents, although vocabulary used sometimes indicates regional voices (e.g. "summat"). As word count analysis was not being undertaken, absolute accuracy and elimination of typographical errors were not essential. Where interviewees appeared certain of their idioms or idiosyncratic use of words these were not corrected; such as the ASHP users who said their unit had saved them 100%, when it had saved them 50% of fuel costs. In addition, one transcript from an interview that an interviewee had undertaken as part of parallel research was also obtained, with the consent of the interviewee. Given that it was the content and intent of the speaker that was of interest, rather than the language used to phrase this, the transcripts can be seen as

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[4] Notes from hydropower installer; Notes on own PV installation; Notes from phone conversations with CES programme manager and CEN programme manager; PV adopter No 24 supplementary notes.

pragmatic. The specific context of the interviews is not part of the transcript (although it is included in the data casebook) and a decision was made not to include descriptions of background noises in the transcript, unless they interrupted the conversation (e.g. by a phone ringing and being answered). The power relations between interviewer and interviewee were not considered to have a significant bearing upon the data and thus analysis focussed on content rather than analysis of the discourse itself (Bucholtz, 2007, Hammersley, 2010).

However, it should be noted that the same researcher undertook all the interviews (with the research accompanied by more experienced researchers for three interviews) and the transcription. The transcripts were created by re-speaking the recordings of the interviews into voice recognition software to create a first draft. These draft transcripts were then checked for accuracy and corrected by the same researcher listening to the audio recording. Thus the researcher who had participated in the original conversation, heard it again through re-speaking it, and listened to the interview for (at least) a third time. This process certainly felt as though it was creating the immersion in data that is recommended in order to undertake content analysis of qualitative data (Mostyn, 1985).

3.9 Analysis

Faced with the extent of the data (62 sets of transcripts and field notes), the analytical challenge is to find patterns in the data, which can then be used to suggest explanatory theories. Analysis must be systematic and objective (Mostyn, 1985) but for this research, a mechanistic approach to word or phrase frequency will not be effective as the data that has been collected describes the case studies from the participants' perspective, describing their lived experience, and therefore greater interpretation and clustering of responses using the analyst's judgement is required. Grounded theory necessitates combing through the data and looking for patterns and emergent properties (Glaser and Strauss, 1967), but given that the conceptual framework developed for this research provided a form of hypothesis to be tested, template analysis allowed the data to be analysed through the lens of a proposed model, looking for evidence that fits with a priori codes (King, 2004, Waring and Wainwright, 2008).

Codes reflecting the conceptual model were established in the computer aided qualitative data analysis software NVivo (NVivo, 2008). The initial codes (represented in Figure 3.6) are all “tree nodes”, allowing them to be nested. The code names were given numbers so that they would appear on the analysis screen in a format similar to the presentation of the conceptual model. Without numbers, the codes appear in alphabetical order.

Further codes were then added during coding as other themes emerged, and as points of interest were noted. These are summarised in Figure 3.7 and the differences between these two sets of codes are considered further in Sections 4.2.6 and 5.1 (cross-case analysis and discussion of implications for theory). The final set of codes concurred with the suggested heuristic of no more than three levels of subthemes and no more than 50 codes in total (Miles and Huberman, 1994). More codes can increase coding errors by demand in finer grained decision making during the analysis process.

NVivo also allows a casebook to be used. The casebook is a form of metadata summary. Each data source is assigned a series of ‘cases’ which can cover the attributes of the data source (e.g. from field notes or transcript) or attributes of the data (e.g. the role of the interviewee, the length of time the interviewee intends to stay at a property, whether the interviewee has a water meter). The casebook offers some analytical value directly and casebook analysis enables the relative importance of different features between cases to be examined. For example, casebook analysis can answer questions such as “How many technology adopters also have water meters?” [Answer: seven adopters stated they do have water meters, eight adopters stated they do not, and 11 adopters did not state whether they did or not.] However, the main contribution of the casebook to analysis is in providing ways of partitioning the dataset in order to analyse subsets. Part of the NVivo casebook for this data is included at Appendix 3.E.

1.0 Factors affecting the intention to adopt
- 1.1 Technology attributes – intention
- 1.2 Location attributes – intention
  - Acquired aspects of location
  - Intrinsic aspects of location
  - Sociodemographic aspects of location
- 1.3 User attributes - intention
  - Attitude towards the action – motivation
  - Perceived behavioural control
  - Social norms
- 1.4 Installation process and design issues – intention

2.0 Factors affecting adoption
- 2.1 Technology attributes –adoption
- 2.2 Location attributes – adoption
  - Acquired aspects of location
  - Intrinsic aspects of location
  - Sociodemographic aspects of location
- 2.3 User attributes – adoption
  - Attitude towards the action – motivation
  - Perceived behavioural control
  - Social norms
- 2.4 Installation process and design issues – adoption

3.0 Factors affecting use
- 3.1 Technology attributes – use
- 3.2 Location attributes – use
  - Acquired aspects of location
  - Intrinsic aspects of location
  - Sociodemographic aspects of location
- 3.3 User attributes – use
  - Attitude towards the action – motivation
  - Perceived behavioural control
  - Social norms
- 3.4 Installation process and design issues – use

4.0 Impact of GT in use

Figure 3.6 Initial tree nodes established for coding in NVivo

Tree nodes added
5.0 Area-based programme issues
Funding
Impacts beyond direct technology impact
Institutions
People
Programme purpose
Technology attributes

6.0 Lifecycle impacts
7.0 Rebound impacts
8.0 Spillover and other green actions

Free nodes added
Curtailment technology
Efficiency technology
Persuasion technology
Note: the free nodes were added to tackle the analysis for one particular case study – RE:NEW, discussed in Section 4.1.1

Figure 3.7 Codes which emerged from analysis

Outputs from the template analysis (analysis of the data organised by nodes) are in the form of collated summaries of all data in a particular code, or set of codes, organised using Boolean terms. An example is included at Appendix 3.F – all data coded to "User factors affecting intention to adopt" for the RECharge scheme[5]. These summaries can then be read and digested further to see what themes emerge and how strongly the different aspects of the template are supported. A visual display of each case was developed and is presented in each of the case study results below (Figures 4.1.1b – 4.1.5b). The display followed the conceptual framework of intention-adoption-use and could be considered a "checklist matrix" (Miles and Huberman, 1994). The matrix then provided the basis for analytic text which interpret the matrix. This analysis had to be referred back to the original data to seek confirmation that inferences were supported by evidence. An illustrative quote or example was identified for each potential finding. There is a risk in following a systematic method that the nuances of rich data can be lost by the

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[5] To offer an example of the data trail through material and analysis, this section of coded data is provided as it links directly to the transcript provided at Appendix 3.D and the coding log entry dated 150311 at Appendix 3.G.

process of summation. Returning to the original data from the case matrix helps mitigate that risk.

A feature of the analysis was the iterative need to 'zoom in' in order to code words, phrases or statements, and then 'zoom out' periodically to see what patterns and themes were emerging. NVivo can report the relative frequency of different codes, which helps to identify patterns and emphasis. Table 3.4 provides an abridged version of this report for illustrative purposes only, showing only the quantity of data coded as relevant to the 'intention to adopt' green technology across all case studies.

Table 3.4: Abridged report of numbers of references for each code

Node	**Number of references**	**From number of data sources**
Factors affecting the intention to adopt	51	28
Technology attributes – intention	94	40
Location attributes – intention	58	32
Acquired aspects of location	10	6
Intrinsic aspects of location	6	3
Sociodemographic aspects of location	5	3
User attributes – intention	145	46
Attitude towards the action – motivation	5	10
Perceived behavioural control	2	3
Social norms	7	9
Installation process and design issues – intention	33	20

It should be noted that as a word or phrase or statement may be simultaneously coded to several nodes, the absolute numbers of references are less interesting than the relative frequency with which different attributes are mentioned[6]. The absolute number of references also needs to be put in context. Are these numbers high, medium or low? Null responses (i.e. areas where a factor is not reported as having any influence) are also of interest as they suggest areas where scheme design may not have any influence, or areas where barriers to adoption are not recognised. Relative descriptors of Strong, Moderate, Weak or Absent were assigned to the numerical values of frequency so that cases could be compared. These descriptors were assigned by looking, for each case individually, at the relative frequency with which different factors were mentioned. In most cases, these values (frequency of a factor being mentioned) were clustered and break points in the values could be identified as the boundaries between a reported strong, medium or weak influence.

In most cases, the partitioning into Strong, Moderate or Weak was straightforward, identifying clusters of frequencies with care taken that ranges should not overlap. In a few cases, greater judgement needed to be exercised in delineating between these categories. For example, Table 4.1.5d summarises the number of times that each of the four sets of factors are mentioned at the three stages of adoption and use in the ERYC ASHP dataset. The ranges for the categories of relative frequency are presented in Table 3.5 below.

Table 3.5 Ranges for frequency of factors in ERYC ASHP dataset

(see also Table 4.1.5d)

Category	**Bottom of range**	**Top of range**
Weak	2	12
Moderate	16	21
Strong	23	26

It can be seen that the ranges are not equal in their magnitude. There is an interval between the maximum value of 'moderate' and the minimum value of

[6] Summing the number of references at the sub-codes will not provide the total number of references at the level of coding above. This can arise because data can be coded at code or sub-code level and is not automatically linked between levels. This discrepancy may also be because data is coded to more than one sub-code.

'strong', but this interval is only one occurrence. The range boundary was therefore confirmed by returning to the full dataset and looking at the strength of assertions made by interviewees, but it is acknowledged that such decisions do lie with the researcher's judgement and may not be completely replicated by another analyst.

A table similar to 3.4 is produced for each case (Tables 4.1.1d – 4.1.5d). The cross-case analysis starts from a stacked table where the level of responses is categorised (Table 4.2.1).

One observation made when comparing these area-based schemes concerns their scale. RE:NEW's scale of ambition was much greater than the others (by a factor of 10 compared to Kirklees and 1000 compared to ERYC and TTT). This makes some cross-case analysis challenging and care is needed to ensure that comparisons are not at mixed scale, from area-based schemes to households, from macro to meso and micro. In these circumstances it is easier to identify the presence or absence of factors than the relative importance of the factors (Vaughan, 2005).

As coding progressed over a period of approximately two months, there were many decisions that needed to be taken over issues such as the precise meaning of a code or the protocol for multiple coding at nodes within the same hierarchical 'tree'. These decisions were recorded in a coding log document which proved both to be a useful tool for reflection, and for ensuring consistency with previous decisions. Alternatively, if after some repetitions a change to coding practice seemed sensible, the log allowed the researcher to go back through the data systematically and ensure consistent use of codes. An excerpt from the coding log is at Appendix 3.G.

Case studies are presented in reducing order of technology maturity, from the most established to the least established. Technology maturity can be assessed through changes in several technology attributes including observability, familiarity and certainty of relative advantage. These attributes can lead to lower capital costs and a developing design which accommodates the user as designs and products evolve though learning and monitoring use by innovators and early adopters (Bhamra et al., 2011).

3.10 Reflections on positionality

The limitations of this method, and therefore on the results that it produces and the conclusions that can be gathered from those results, are discussed more fully in Section 5.1. However, at this point it is worth reflecting on the particular possible limitations associated with positionality. The factors that shape positionality might include a researcher's social or cultural position or other attributes that would affect the questions that researcher asks and how they frame them; the theories they are drawn to and, from those preferences, interpretations they place on empirical evidence; how research participants respond to them which in turn influences access to data and institutions; and the likelihood that they will have impact through attributes which make them more or less likely to be listened to (Jackson, 2009a). Recognising positionality means recognising that all knowledge is partial and comes from a particular perspective. This does lead to the conclusion that all qualitative data is subjective, but it does imply that attending to positionality offers a route to greater objectivity (Jackson, ibid).

The researcher is female, in her mid-40s, a parent, white, professional and educated and without a strong regional accent. She is a home owner in West Yorkshire and has, during the period of this research, installed her own set of PV panels. She is also experienced in project management and in facilitation. This provided some advantages for data collection as the researcher had skills to draw on in establishing a rapport, open questioning and empathising. In some cases, the interviewees saw the interviewer as expert and sought her opinion on matters of technology selection. Recognising these qualities in the interviewer is consistent with an approach termed “responsive interviewing”, primarily concerned with obtaining the participants’ interpretations of their experiences (Rubin and Rubin, 2005) and working in a flexible and adaptive way to gather those interpretations, without imposing the interviewer’s views. The need for a type of “emotional/rational schizophrenia” has been described as essential for case studies with a small number of cases; the interviewer must be empathetic yet dispassionate (Harper, 2005).

However, despite experience as a facilitator and open interviewer, as far as development of qualitative research is concerned, the interviewer was far from expert at the outset of the process! A lack of experience in recording and analysing semi-structured interviews was compensated for by carrying out interviews over several months, with pilot interviews interwoven with analysis, to ensure that data generated was consistent and usable.

Having established a path from area of enquiry and research questions, to research philosophy, strategy and tactics or method to answer those questions, Chapter 4 summarises the results from following that method.

Chapter 4 Results

4.1 Case studies

Each of the five case study area-based schemes are presented separately in Section 4.1. Section 4.2 then looks across all five cases to identify themes and patterns in cross-case analysis. The case studies are presented in order of the maturity of the technology that they promote, starting with RE:NEW's well-established and economically beneficial 'easy measures', moving to WarmZone's focus on cavity and loft insulation (which is well established but still being amended in terms of optimum design and installation), through PV in Totnes, to the range of microgeneration measures in RECharge, and finally considering the still novel air source heat pumps in the East Riding of Yorkshire. The format of the case study presentation is as follows:

- A summary of the case study scheme and a table of characteristics providing the factual description of the main dimensions of the case;
- A timeline and listing of the critical events that delimited the main stages of the development and implementation of the scheme;
- Analysis and comment on this case study data, organised by the three stages of intention, adoption and use, drawing on the full set of qualitative data and using quotations from the data to illustrate the analysis; and
- A summary 'checklist matrix' of the factors that were identified by different interviewees at different stages of the adoption process (an expanded presentation of the data is included in Appendices at 4.1) and is also presented graphically in a format consistent with the conceptual framework developed in Chapter 3 and shown in Figure 3.5.

4.1.1 RE:NEW London

4.1.1.1 Summary of case study scheme

RE:NEW London is an umbrella scheme established by the Greater London Authority (GLA) led by the Mayor of London. It aims to retrofit and improve the energy efficiency of 1.2 million properties across London by 2015. The GLA provides match funding for London Boroughs who then contract with a managing agent to deliver home energy advice visits in a defined area. The home energy visits are undertaken by 'Green Doctors' who provide a simple energy audit, advice on how to reduce energy costs, install 'easy measures' and arrange for cavity and wall insulation to be installed, if required. This case study sampled views and experiences from facilitators, installers (Green Doctors) and adopters in two different areas of London: Hillingdon in the west and Sutton in the south. Both areas were using similar methods and identical funding.

Table 4.1.1a Characteristics of RE:NEW London

Data additional to fieldwork data sourced from The London Assembly (2012b, 2012a)

Scheme characteristics	Comments
Technology promoted	Energy conservation through persuasion, efficiency and curtailment.
Interventions	'Easy measures' installed during adviser visit included wireless energy display monitors, draught proofing, powerdown plugs, chimney balloons, CFLs, tap flow restrictors, low flow showerheads and shower timers. Energy conservation advice offered (e.g. use of heating controls). Assessments made on the need for cavity wall and loft insulation, and appointments made where required. Assessment for grants towards replacement boilers.
Desired outcomes/drivers	Reduced energy bills.
Performance measures	Number of households supported. Carbon savings estimated from measures installed. Estimated to be over 400,000 tes carbon.

Scheme characteristics	Comments
Geographic location / settlement description	Urban neighbourhoods of around 1400 homes. Selected by local authorities using a variety of criteria. Heat mapping identified targets in one area. Another area (14 streets total) had been nominated as a 'low carbon zone' and was close to a well-known 'eco settlement', as well as comprising a wide variety of housing types and tenure.
Scale of funding	Anticipated budget was £5.8M (2011 prices) from central funds over four years. Spend from 2009 to May 2012 was £7.8M.
Outputs	Programme managers anticipated reaching 50,000 homes across London in the first year. Project documentation produced at the start of 2011 stated the long-term aim of RE:NEW was treating 1.2M homes by 2015. RE:NEW reported visiting 67,568 homes to June 2012 but this may also include technical trials and Home Energy Efficiency Pilots (HEEP) (8119 homes).
Accountable / lead body	GLA, supported by the Energy Savings Trust (EST), managed the programme and co-ordinated projects within all London Boroughs.
Partners	Hillingdon programme managed by Groundwork Thames Valley. Sutton programme managed by CEN (Community Energy Networks). Both are not-for-profit organisations, although this does not apply for all possible managing agents on the RE:NEW framework. Equipment provided by the big six energy companies as part of CERT commitments and by Thames Water.
Contract form for delivery	GLA competitively tendered for management agents on a framework agreement and Boroughs then ran mini-competitions to appoint managing agents for their schemes within the framework.
Start date for delivery	Programme had been running HEEP with technical trials in 2009 and a pilot programme until March 2010. Mayoral approval of the budget was being awaited at the times of interview data collection (April 2011).
Duration of delivery	Initially seeking commitment to run for 12 months (until April 2012 and London mayoral elections). Project still appears live in December 2012 although seconded project manager has returned to EST. RE:NEW2 funding has been announced as £3M to be allocated to retrofit a further 24,000 homes by the end of 2012/13.

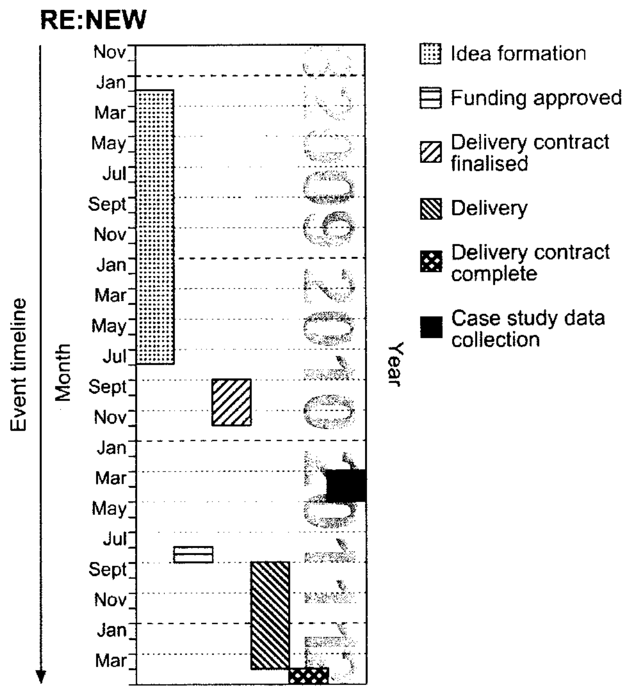

Figure 4.1.1a RE:NEW London event timeline

Table 4.1.1b RE:NEW London event listing

Event / stage	**Timing**
Idea formation	2008 from Mayoral energy team. 2009 technical trials: Technical trials were completed in the summer of 2009, in the areas of Croydon, Hillingdon and Southwark. 817 homes were treated which resulted in approximately 500tes CO2 saved through easy measures. 2009-10 HEEP pilots in 5 London housing areas. Demonstration projects took place between 2009 and 2010 in nine boroughs: Camden, Croydon, Haringey, Harrow, Havering, Hillingdon, Kingston, Lewisham and Southwark.
Funding approved	August 2011
Delivery contract finalised	Managing agents recruited to framework in Dec 2010
Delivery started	September 2011
Delivery contract complete	RE:NEW1 April 2012
Case study data collection	April – May 2011

4.1.1.2 Case data

Table 4.1.1c below summarises the number of times that each of the four sets of attributes (place, technology, user and installer) were mentioned, with the relative frequency of mentions leading to categorisation as Absent, Weak, Moderate or Strong. This table partitions data by interviewees' roles, and further detail is provided in Appendix 4.1A in order to understand the types of attributes referred to.

Table 4.1.1c Factors affecting technology adoption and use identified by different roles

	Attributes	**Intention**	**Adoption / non-adoption**	**Use**
Adopter	Place	1	3	0
N= 2	Technology	1	7	0
	User	0	2	6
	Installer	4	2	4
	Other	1 (see Table 4.2.2)		
Non-adopter		No data	No data	No data
Facilitator /	Place	6	5	0
Manager	Technology	5	6	1
N=4	User	6	3	1
	Installer	5	2	4
	Other	1 (see Table 4.2.2)		
Installer /	Place	4	4	0
Surveyor	Technology	2	11	5
N=2	User	4	5	3
	Installer	5	10	0

4.1.1.3 Commentary on results

Factors affecting intention to adopt

Users, installers and facilitators all held 'place' as having have a role in shaping the intention to adopt resource conservation technologies promoted through RE:NEW. They mentioned a wide variety of place factors including intrinsic characteristics of the area such as water hardness, housing type and density, as well as sociodemographic factors. The role of social networks or community groups in providing the conduit to share information about the scheme was mentioned several times, indicating an acquired place factor which helped shape the intention to adopt.

The influence of user characteristics in general is spread fairly evenly through all stages, although the specific types of user characteristics which have influence vary through the adoption process. Facilitators and installers both reported the importance of user characteristics in being able to recruit households at all. They saw potential adopters' attitudes as the critical threshold characteristic, recognising that some people were unwilling to receive the advice because they had other priorities, were too busy, or simply rejected the intrusion. Facilitators focussed on how to shape the adoption, how to achieve 'market penetration' for the advice offered in a particular area. User characteristics were mentioned less than the attributes of a technology which might make it of interest to users. Installers and facilitators felt they might be able to influence attitudes by highlighting the potential cost saving from a Green Doctor's visit or the relative advantage that the technology offered by the visit might provide:

> *"It's very informal. I just say I'm here, I'm here to help you save money on your gas and electric bills and I've got loads of free stuff to do, so why wouldn't you invite me in?" [Installer, RE:NEW]*

However, there was no evidence that the relative advantage of the technology would overcome a potential user attitude of the type described as a barrier. The installers placed more focus on users than facilitators did at this stage.

Adopters had little to say about how the intention to adopt was formed. It seemed very straightforward in their eyes; the trigger of fuel costs meant they were open to suggestions about how to reduce resource use.

Factors affecting adoption

Adopters mentioned perceived behavioural control, where they felt unable to act on their own, as a limitation on adoption, and this limitation was overcome with the Green Doctor's visit and advice. There is a variation in the perception of the importance of installers and the installation process depending on the role of the interviewee. Installers did not see their own impact at the use stage, but placed importance on their role in the adoption stage, recognising that the way they approached the householder and tried to understand what drove their behaviour would help their advice take hold and ensure the easy measures were accepted. Installers also understood the need to demonstrate the relative advantage of a technology in a way that really struck home with the potential adopter. In one visit, while using the wireless energy monitor to demonstrate the running cost of different appliances, the adopter shrieked her surprise when the electric shower was turned on. The installer later remarked:

> *"The shriek at the energy monitor is the result I'm gunning for!" [Installer, RE:NEW]*

Users, installers and facilitators also all held place as having a role in the adoption of resource conservation technology. At the adoption stage, more mention was made of the intrinsic place factors like housing design and the specific constraints on technology installation (e.g. the difficulty of insulating ceiling corners which stick out beyond a roof line). Water hardness, an intrinsic place factor, was also mentioned as a specific issue which helped with the adoption of water conservation measures since flow through appliances was often poor already. The following quote illustrates both this point and the installer's awareness of the need to suggest trialability in order to overcome an adopter's reluctance (in this case for a showerhead with flow control):

> *"Because it's so quick to put on, I normally have been putting it on and saying, 'Oh, well, we'll just try it and see.' And because of the design, they actually give you a better apparent pressure, and also, particularly in this area, we have very hard water, so six times out of ten, the old showerhead is pretty scaled up so actually it's improving their service." [Installer, RE:NEW]*

Technology considerations dominate the adoption stage. The cost of the technology (which interacts with the user's perceived ability to afford the technology, notably for items like double glazing or efficient boilers) was the main concern of adopters and the relative advantage provided by the technology in reducing fuel bills was not sufficient to motivate adoption without the home energy advisor's help. Installers demonstrated a sophisticated understanding of the technology attributes beyond technical performance. They noted the appeal of visibility and the 'gadget factor' in the wireless energy monitors, also recognising that this appeal was demographically dependent and less important for the elderly. Installers also stated that the visual appeal and compatibility of the technology with the homeowner's existing systems and aesthetic was a critical factor in adoption:

> *[Referring to the low flow showerhead] "This comes back to the shiny thing. I don't know whether you've seen one of them but they're very nice, faux chrome things, they look nice and they look good. And in fact the bottom line of where stuff gets in or not is whether or not somebody feels it's in keeping with their house." [Installer, RE:NEW]*

Factors affecting use

Users, installers and facilitators did not identify place factors in discussing the impact of the technology in use. Installers reported that their own influence was heavily constrained in terms of achieving the desired impact on resource consumption. Installers recognised that the adopter's norms and habits were most powerful in how technology was used:

> *"Like, one person who when I was talking about, 'Well, you might want to turn the thermostat down a little because each degree on there is 10% of the heating bill.' And he goes, 'This is the 21st century?' And he was obviously wearing his shorts and T-shirt. 'I don't do jumpers inside the house!' It was like well, okay, that's fair enough, you pay the bills that's your choice, but your bills will be a bit higher so, so it's trying never, I suppose you never want to be combative." [Installer, RE:NEW]*

Installers also mentioned the role of other tradesmen who influenced the household. As an example, a device called an "eco-beta" which turned an ordinary toilet flush into a dual flush is unfamiliar to many plumbers and one installer explained how he always left his mobile phone number so the householder could call him when, almost inevitably, their usual plumber wanted to remove the device. Consistent with this, both adopters and facilitators perceived the importance of the installer as higher at the adoption stage than in use.

The installers placed more focus on user characteristics influencing use than facilitators did, and also brought technology attributes to the fore in considering the use of the technology. It is worth noting that installers understood the risk of discontinuance:

> *"With the thermostat it's impossible you might say, "Well, you might just want to nudge it down and shall I just do that?" Obviously somebody could whack it up a bit later on." [Installer, RE:NEW]*

They felt that discontinuance would be driven by the fit with user norms and routines. Appearing to agree with this, adopters emphasised their norms and routines as the main influence on how they used the technology, whether that be an expectation of internal temperatures for space heating, a dislike of using the tumble dryer when drying clothes outside is possible, or a belief that tea tastes better when water is boiled in a pan rather than a kettle.

Other results from the RE:NEW London case study

From the scheme description, one aspect of RE:NEW to highlight is the scale of ambition in terms of the numbers of properties to be retrofitted across London. This means that the scheme's structure puts a lot of levels of decision making and reporting between the overarching goals and the interactions with the householder. The cross-case analysis will return to compare this to other schemes with a smaller scope in terms of properties to be tackled in Section 4.2.7. A London-specific acquired place factor mentioned by facilitators and installers was parking arrangements. The difficulty of arranging parking permits or of getting vehicle access sufficient for cavity wall insulation installation were particular challenges.

Another feature of this case study is the variety of technologies being promoted (see Appendix 1 and "Interventions" in Table 4.1.1a). These technologies all have the common thread of reducing resource consumption but contribute to this aim in different ways: curtailing resource use (e.g. flow restrictors), increasing efficiency of resource use (e.g. insulation), or making resource use visible in order to provide triggers to change behaviour (e.g. wireless displays). In order to be able to analyse the RE:NEW data, the technologies needed to be partitioned again by their function, assigning data to three additional analytical 'free nodes' outside the conceptual framework. These three free nodes were curtailment, persuasion and efficiency (see Figure 3.7). The theoretical implications of this need to extend the conceptual framework are discussed in Section 5.1.4 below.

4.1.1.4 Case data summary

Collapsing the responses from different roles (Table 4.1.1c) gives a summary of what factors were reported as influential at the different stages of adopting resource conservation measures in the RE:NEW programme presented in Table 4.1.1d. The relative frequency with which factors were mentioned is assigned Strong, Moderate or Weak in order to facilitate comparison with other cases with different sample sizes. While all four types of factors were mentioned as influential at both intention and adoption stages, technology attributes received least attention in shaping the intention to adopt but were considered very important in adoption itself. The use (and impact) of technologies received overall less attention, but where they were discussed, user characteristics were considered to be the strongest influence.

Figure 4.1.1b shows the same data graphically, with the thickness of the horizontal arrows indicating the strength of the reported relationship.

Table 4.1.1d Summary data for factors affecting the adoption of resource conservation 'easy measures' in RE:NEW London

	Place	Technology	User	Installer
Intention	11 Moderate	8 Weak	10 Moderate	14 Moderate
Adoption	12 Moderate	24 Strong	10 Moderate	14 Moderate
Use	0 Absent	6 Weak	10 Moderate	8 Weak

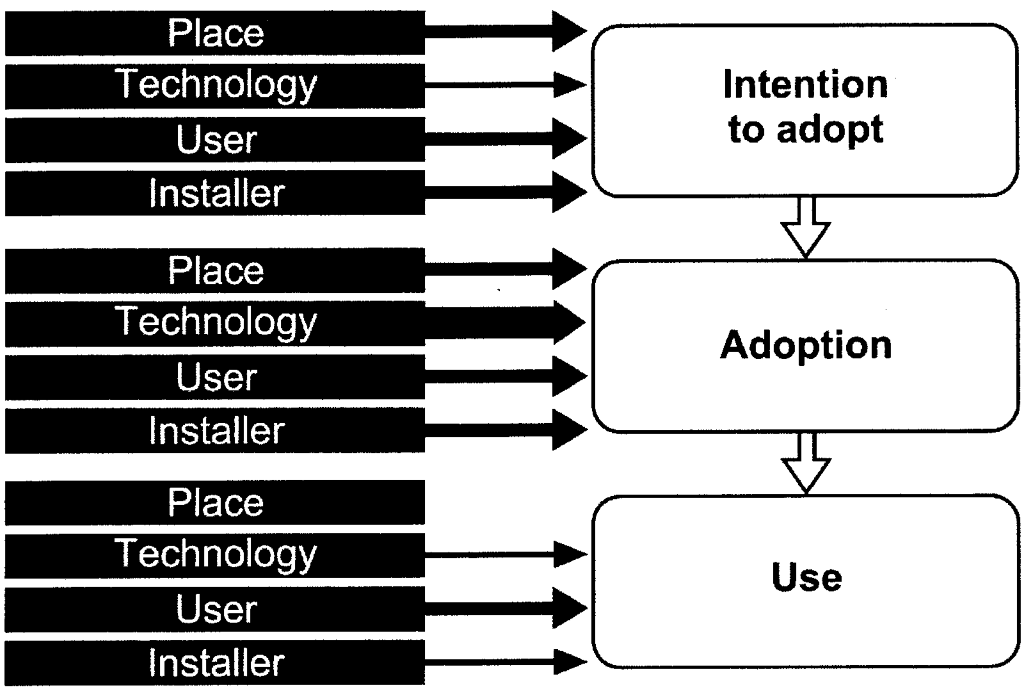

Figure 4.1.1b Illustration of data summary for RE:NEW London

4.1.2 WarmZone Kirklees

4.1.2.1 Summary of case study scheme

WarmZone Kirklees was a three year project intended to make a step change in the home energy consumption across the borough of Kirklees by offering all households free loft and cavity wall insulation, where technically feasible. Supported by cross-party political commitment, and accelerated by a financial windfall from Kirklees' share of the sales of Leeds–Bradford International Airport, the project is notable for its scale and impact. The Council established a community interest company, Kirklees Energy Services, now Yorkshire Energy Services (YES), to manage the WarmZone project (and to manage other energy-related projects for the council). YES competitively tendered for the delivery of the insulation installations and the whole contract was awarded to Miller Pattison who established a new depot at Cleckheaton to deliver the contract. YES made the initial contacts with householders and then passed lists of leads for assessment to Miller Pattison for home visits.

Table 4.1.2a Characteristics of WarmZone Kirklees

Data additional to fieldwork data sourced from Butterworth et al., 2011, Kirklees Council Environment Unit, 2011, and Liddell et al., 2011

Scheme characteristics	**Comments**
Technology promoted	Cavity wall and loft insulation.
Interventions	Every home offered free installation of cavity wall and loft insulation if technically feasible, low energy lightbulbs, a carbon monoxide monitor, benefit checks.
Desired outcomes / drivers	Reduction in fuel poverty. Reduction in energy consumption in (and therefore carbon emissions from) the borough. Improve the uptake of state benefit support. Job creation.
Performance measures	Households advised. Households insulated (translated to carbon savings).
Geographic location / settlement description	Kirklees is a unitary local authority in the north of England, centred on the town of Huddersfield but covering a range of urban, semi-urban and rural areas in the north Pennines. Population approx. 401,000 in 171,000 homes.
Scale of funding	£24M WarmZone spending.

Scheme characteristics	Comments
Outputs (relevant to research questions)	165,686 households visited. 42,999 loft insulation installations. 21,473 cavity wall installations. (51,155 households combined.)
Accountable / lead body	Yorkshire Energy Services CIC reporting to Kirklees Council.
Partners	Miller Pattison Ltd. Scottish Power (and eaga Ltd. as the outsourcing vehicle for Scottish Power's CERT activities). West Yorkshire Fire and Rescue Service. Yorkshire Water. Benefits agencies including Citizens' Advice Bureau.
Contract form for delivery	Competitively tendered for insulation installation.
Start date for delivery	April 2007
Completion of delivery	March 2010

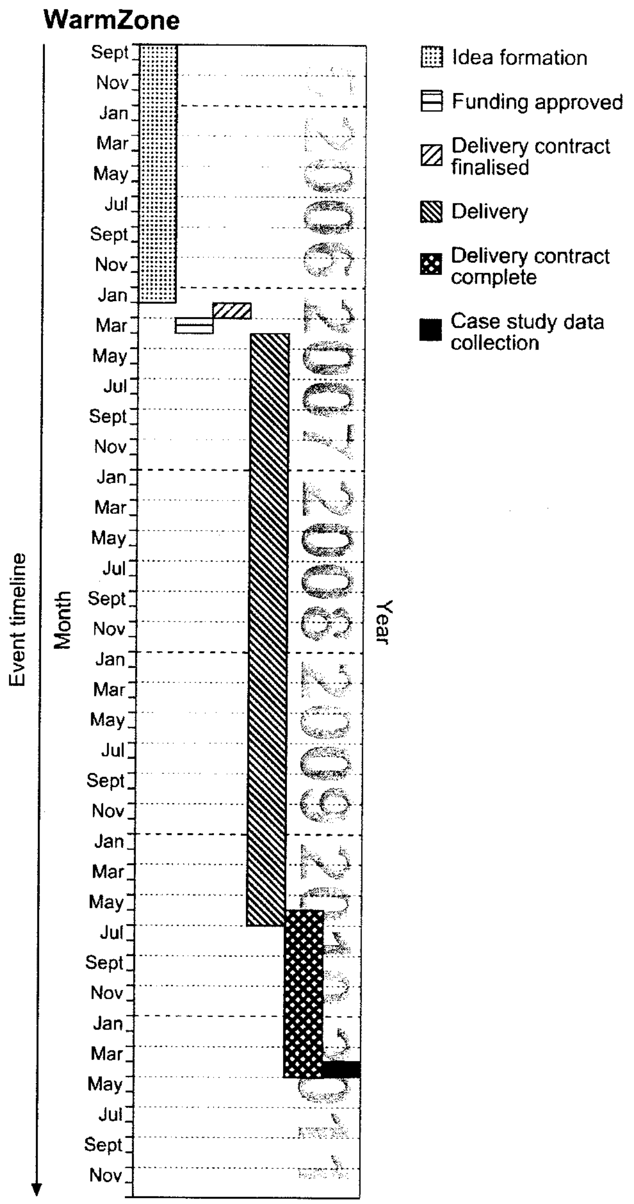

Figure 4.1.2a WarmZone Kirklees event timeline

Table 4.1.2b WarmZone Kirklees event listing

Event / stage	**Timing**
Idea formation	One interviewer suggested that the Rio Summit 1992 had been influential on the head of environment services and the then leader of the council. Both of whom had been to Rio. Action to improve energy efficiency of housing stock started with an opposition motion passed in 2000. Affordable Warmth Strategy 2006 developed after councillor visit to WarmZone schemes elsewhere (Newcastle late 2005).
Funding approved	March 2007
Delivery contract finalised	February 2007
Delivery started	April 2007, with recruitment and project design by YES amended July 2007. At full scale by December 2007.
Delivery contract complete	June 2010 (related work under existing contracts ran until April 2011)
Case study data collection	April 2011

4.1.2.2 Case data

Table 4.1.2c summarises the number of times that each of the four sets of attributes (place, technology, user and installer) were mentioned, with the frequency of mentions leading to a categorisation as Absent, Weak, Moderate or Strong. This Table partitions the data by interviewee roles. Further detail is provided in Appendix 4.1B in order to understand the types of attributes mentioned.

Table 4.1.2c Factors affecting technology adoption and use identified by different roles

	Attributes	**Intention**	**Adoption / non-adoption**	**Use**
Adopter	No data	No data	No data	No data
Non-adopter	No data	No data	No data	No data
Facilitator / Manager N=2	Place	2	5	0
	Technology	1	4	1
	User	2	0	1
	Installer	0	2	0
Installer / Surveyor N=1	Place	1	2	0
	Technology	2	4	0
	User	2	1	1
	Installer	1	9	1

4.1.2.3 Commentary on results

Factors affecting intention to adopt

Place factors were mentioned as having influence in shaping the intention to adopt. The place factor mentioned most was the acquired attribute of the local authority profile on green issues, which led to offering insulation as a universal benefit.

User characteristics were also mentioned in the intention to adopt stage, or rather, how user characteristics, notably attitudes, were a barrier to forming the intention to adopt. The attitudes referred to were not necessarily environmental or specific to energy or insulation, rather a more general attitude of apathy, being anti-public sector intervention or simply too busy with other things. These were problematic for managers; installers rarely got to meet such users as they only met users once the intention to adopt was formed.

Factors affecting adoption

More references to place factors were made in discussing adoption. Again, the acquired place attribute of the council's high profile approach to energy and environmental issues was noted. The intrinsic place characteristics of building types, age and density were also mentioned as these place characteristics determine the degree to which insulation technologies can be used. The reputation of the installer in the area, a positive one, and the high level of visibility developed because of the nature of the scheme, were also mentioned as important in ensuring households moved from intention to adoption. The apparent strength of installer factors reported at the adoption stage reflects the level of understanding demonstrated by the installer interviewed in terms of the complexity and potential impact of his approach.

While both scheme managers and installer recognised the importance of technology attributes in adoption, they emphasised different aspects. Managers focussed on the attributes of the technology in use: its visual intrusion, noise or need for maintenance. The installer was more concerned with what could be termed the technology's 'compatibility', how much disruption would be caused by the insulation installation and what the installer could do to reassure the householder that this disruption would be minimal. The installer made a direct connection between how he and his team presented themselves and how the householder would perceive the technology. He believed that the installer attributes would be used as a proxy for technology attributes in the decision to adopt. For example, wearing overshoes into a property, appearing smart and in a clean company uniform, and acting quickly to rectify any mistakes or collateral damage were all seen as important in ensuring the householder felt positive about the technology.

Factors affecting use

Place factors were not mentioned as important in the use of technology. Indeed, the nature of the technology, insulation, means that very little was said about the use phase at all. Once installed, the insulation should do its job although installers were aware of scepticism over actual performance and refer to user characteristics, particularly previous experience or out-dated knowledge from the building trade, as the key factor in such user scepticism.

4.1.2.4 Case data summary

Collapsing the responses from different roles (Table 4.1.2c) gives a summary of the factors reported as influential at the different stages of adopting insulation through WarmZone, Table 4.1.2d. The difficulty of accessing adopters and the apparent impossibility within the research's available time and resources of reaching non-adopters mean that this case study's data is focussed upon the views on the scheme managers and those tasked with installing household technology at scale. This is a different perspective compared to that offered by the other case studies. The relative frequency with which factors were mentioned is assigned Strong, Moderate or Weak in order to facilitate comparison with other cases with different sample sizes. The installer demonstrated an in-depth understanding of how he and his team might influence the user household, leading to a reported 'strong' influence for installer/installation attributes. Place factors, particularly acquired place factors, were important in shaping the intention to adopt, but adoption itself is dominated by the constraints and opportunities afforded by the technology.

Table 4.1.2d Summary data for factors affecting the adoption of insulation in WarmZone Kirklees

	Place	Technology	User	Installer
Intention	3 Moderate	2 Weak	4 Moderate	1 Weak
Adoption	7 Moderate	8 Strong	1 Weak	11 Strong
Use	0 Absent	1 Weak	2 Weak	1 Weak

Figure 4.1.2b shows the same data graphically, with the thickness of the horizontal arrows indicating the strength of the reported relationship.

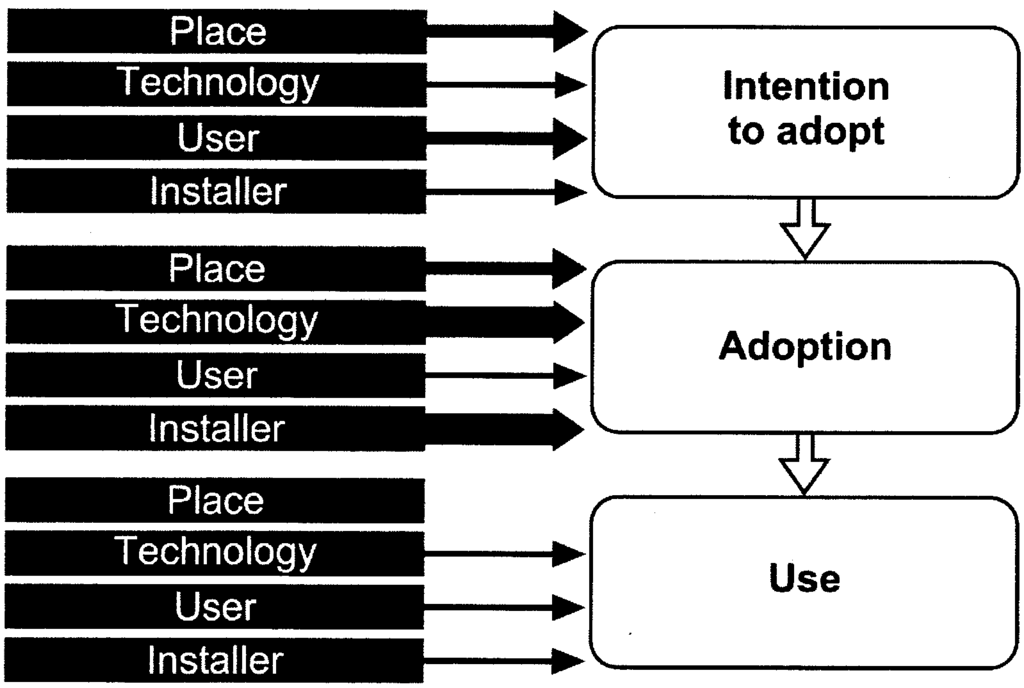

Figure 4.1.2b Illustration of data summary for WarmZone

4.1.3 Transition Streets Totnes

4.1.3.1 Summary of case study scheme

Transition Streets Totnes was a programme which focussed on establishing peer learning groups among neighbours, termed 'Transition Together', aimed at increasing awareness of energy resilience issues, increasing capacity and action to reduce energy consumption, and increasing renewable energy generation. Grant support towards the installation of photovoltaic (PV) panels was available to households who completed the peer learning programme. Funding for the PV installations came from the DECC Low Carbon Community Challenge.

Table 4.1.3a Characteristics of Transition Streets Totnes

Data additional to fieldwork data sourced from Ward et al., 2011 and Hopkins, 2008.

Scheme characteristics	**Comments**
Technology promoted	Photovoltaic cells – typically 6 panels with a capacity of 1.1 kWp.
Interventions	Grants offered approximately 50% of PV installation cost for eligible households. Households were eligible if they participated in the Transition Streets programme. Transition Streets Totnes was a programme which encouraged groups of neighbours to self-organise and go through a workbook which introduced ideas about low carbon and resilient living.
Desired outcomes / drivers	Increased understanding of and action on Transition issues.
Performance measures	Number of Transition Streets groups formed. Number of households involved. Percentage of low income households included. Number of PV installations.
Geographic location / settlement description	Totnes, a market town in South Devon, south west England, population approx. 8,000, was the first place to start a 'Transition Town' community-based movement, aiming to engage the community in positive actions to increase resilience and reduce dependence on fossil fuels.
Scale of funding	£625,000 from DECC for the PV elements of the programme plus £32,500 from other charitable sources for the establishment of the Transition Together programme.
Outputs (relevant to research questions)	141 grant-aided PV domestic installations. 468 households formed 56 Transition Streets groups.

Scheme characteristics	Comments
Accountable / lead body	Transition Town Totnes
Partners	South Devon Housing Local authority: South Hams District Council Energy Savings Trust DARE/Energy Action Devon – a local NGO Wessex Home Improvement Loans (a community development finance institution)
Contract form for delivery	TTT competitively tendered for the PV installations in two waves. Beco, a locally based firm now part of the Kier Group, won both tendering rounds.
Start date for delivery	January 2010
Completion	April 2011

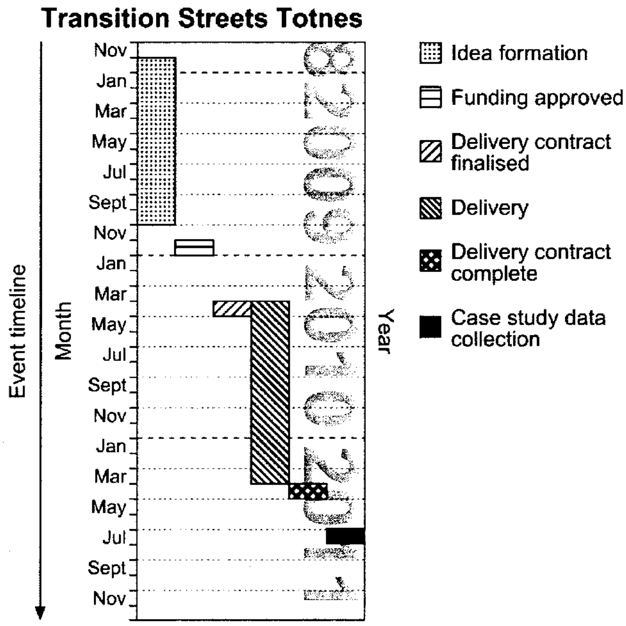

Figure 4.1.3a Transition Streets Totnes event timeline

Table 4.1.3b Transition Streets Totnes event listing

Event / stage	**Timing**
Idea formation	Early 2009, from key individuals in Transition Together pilot group.
Funding approved	Dec 2009 Capital expenditure complete by March 2010.
Delivery contract finalised	April 2010
Delivery started	Wave 1 of applications started April 2010, with 80 installations until September 2010. Wave 2 of applications started October 2010, with 70 installations until April 2011.
Delivery contract complete	April 2011
Case study data collection	July 2011

4.1.3.2 Case data

Table 4.1.3c summarises the number of times that each of the four sets of attributes (place, technology, user and installer) were mentioned, with the frequency of mentions leading to categorisation as Absent, Weak, Moderate or Strong. This table partitions the data by interviewees' roles. Further detail is provided in Appendix 4.1C in order to understand the types of attributes referred to.

Table 4.1.3c Factors affecting technology adoption and use identified by different roles

	Attributes	Intention	Adoption / non-adoption	Use
Adopter N=6	Place	1	6	0
	Technology	6	8	5
	User	10	5	9
	Installer	2	8	0
	Other	-	1 (see Table 4.2.2)	1 (see Table 4.2.2)
Non-adopter N=4	Place	8	5	0
	Technology	9	13	1
	User	18	10	3
	Installer	0	2	0
Facilitator / Manager N=1	Place	1	6	0
	Technology	0	4	1
	User	1	4	2
	Installer	0	0	0
Installer / Surveyor N=1	Place	2	6	0
	Technology	3	5	3
	User	4	2	4
	Installer	7	4	4

4.1.3.3 Commentary on results

Factors affecting intention to adopt

Place was mentioned by all roles in shaping the intention to adopt, although non-adopters emphasised issues of place most frequently at this stage. In shaping the intention to adopt, non-adopters put more emphasis on the acquired attributes of place, both social and cultural norms. Active participation in action for sustainability was felt to be more prevalent in Totnes than elsewhere. Non-adopters also commented more than adopters on the visibility of the PV installations that had appeared across the town than adopters.

Adopters and non-adopters alike emphasised their personal interests, knowledge and situation, such as having just moved into the street, more than issues of place in what led them to consider installing PV. Installing PV was seen by adopters and non-adopters in the context of a broader range of actions promoted by the Transition Streets Programme. Personal characteristics, such as life stage or experience, influenced the way in which these actions were viewed.

> *"I just thought, 'Actually I don't think this is how I want to spend an evening.' Which is a bit lame maybe. But I just thought actually I don't want to…because people were very excited, it seemed, about all coming together, they seemed to be quite, you know, lots of young children and let's all grow vegetables and we can share seeds and if I have too many carrots, you can have some of my carrots and it all seemed to be rather petty little Transition actions… I feel, at a different time in my life I would have been quite interested in that. And now it doesn't really float my boat." [Non-adopter, Totnes]*

Both these groups also mentioned the attributes of the technology – its cost, performance and also visual appearance – in their intention to adopt, more than place factors. The installer was the only interviewee who felt that installation-related factors, including the advice given by the installer when specifying an installation, were influential at this stage. The installer's awareness of this influence was linked to the fact that he was himself part of the community and felt the responsibility of doing his job effectively, for community benefit:

> *"I live in the town as well, so I see these people every day and I don't want to be doing anything which is going to be upsetting people. Very difficult. Because the way the Feed-in Tariff is structured as well, and with the grant, it became so financially generous that it probably would allow an installation in a situation where it wouldn't be optimal but would still pay back quite generously. So I had to have that head on as well as my environmental head, thinking is this a good use of resources and taxpayers' money, with resources to make the panels? And also do I want to put my name to that?" [Installer, Totnes]*

Factors affecting adoption

The role of place in ensuring adoption was dominated by acquired place factors. Several interviewees, adopters and non-adopters, suggested the physical attributes of place – the fact that their street was a cul de sac with experience of gatherings and street parties across the street as well as along its length, as well as there being no walls between the gardens of the terraced houses on one side – made a substantial difference to information sharing and sense of community. The availability of grants to make PV systems more affordable was mentioned repeatedly as an acquired place characteristic which altered the potential adopter's perceived behavioural control (PBC). The support provided through Transition Streets in providing a known and trusted installer rather than each household having to go through procurement was also seen as a real benefit of being part of the area-based scheme. Another notable acquired place factor was the shared knowledge and experience, facilitated by the peer learning aspects of the Transition Streets Totnes programme. For example, when one adopter overcame feasibility problems by suggesting siting the panels on a garage roof, two neighbours quickly followed suit.

The picture presented by non-adopters of the factors that led to non-adoption after they had considered PV were not uniformly against the technology, but more a balance of considerations with the technology attributes as the focus. Non-adopters had evaluated whether the relative advantage provided by the technology was real for them. Would PV increase the comfort of their house? Non-adopters justified their decision in terms of the rapid development of technology and suggested that something more efficient and effective than PV would be sure to be available soon. Non-adopters were also more likely to place PV in the context of the whole house, with one couple describing:

> *"The solar panels, for example, a two grand grant or whatever it was Transition Streets [were offering] basically meant to put solar panels on the roof, we'd be sticking solar panels on that crap dormer, really we should fix that Dormer, so we should fix that and if we're going to fix that then really we should do that work on the whole top floor so suddenly a two grand grant is turning into twenty-five, thirty grand project, you know, so we haven't gone ahead." [Non-adopter, Totnes]*

The technology attributes which had been most appealing to the programme managers were the modularity and ease of buying the panels in bulk at a stage when the precise nature of the homes that would be retrofitted were unknown. The appeal of PV from the managers' perspective was critiqued, correctly, by non-adopters as meaning the PV did not really tackle the causes of their resource consumption patterns. One adopter spoke of his wish to install solar thermal rather than PV as it seemed a more effective technology in achieving environmental aims. When originally considering solar thermal, his property had been tenanted and the boiler had broken down during winter so a quick solution was required. He considered solar thermal too complicated to install quickly. This reinforces the idea that investment in microgeneration is likely to be a planned purchase, while in many cases, replacing a heating system is a distress purchase.

The importance of the user characteristics of attitude and PBC (improved by the grant availability) were also recognised at the adoption stage of decision making. Alongside this, technology attributes and place attributes were intertwined; the age and condition of the roofs in older properties making it difficult to place the rails and tiles for the panels securely is one such example.

A final factor to note in adoption was the nature of the scheme management. In addition to being accessible and unbureaucratic (a point returned to in 4.2.7, cross-case analysis, below), decision-making was rapid and the elapsed time between the survey and being able to schedule installation was very short. One adopter noted how this pushed him into adoption:

> *"I then talked to them about installation and they said we can do it either next week or in about six weeks' time at which point I gulped and said. 'We'll go for next week,' and wrote a cheque... It was great from my point of view because it led me to make decision rather than kind of bringing [in] all sorts of negativity and what ifs, so it was just, 'Are we going to go for it?' 'Yeah, let's go for it.' " [Adopter, Totnes]*

Factors affecting use

Place was not mentioned as a factor that affected the use of PV. In terms of use of the system, it is worth acknowledging that correctly installed PV will carry out its design function, generating electricity when sunlight is incident on the panels, and exporting that electricity to the electricity distribution network. Thus the discussion of the use of PV here focuses more on whether the household takes advantage of PV-generated electricity to reduce the amount of electricity that they import from the grid by managing their appliance function and load. If timed during daylight hours and particularly when the sun is out, actions such as running the washing machine or dishwasher or recharging batteries will use the PV-generated electricity before drawing on the grid. Four of the six adopting households changed their habits and routines in this way. Both adopters who did change habits and those who did not suggested that user characteristics were most important in achieving any reduction in resource consumption through this means. In particular, an understanding of what technology does and a willingness to monitor and review the household's behaviour and impact in order to adapt and respond to the opportunity afforded by PV were critical. If individuals self-defined themselves as being uninterested in the technology and not having habits, then any reduction in resource impact was reliant on the determinant nature of the technology:

> *"I just hadn't thought of that at all. I don't do technical. Yes. I'm not sure ... I don't know would it make more sense for me to run things in the day, I'm not sure, it might do, mightn't it?"...[later]... "My routine is not having a routine." [Adopter, Totnes]*

The installer was aware of the potential for PV installation to bring wider benefits in reducing resource consumption and considered it part of his role to highlight these benefits:

> *"That's my personal crusade here, is the energy awareness." [Installer, Totnes]*

To achieve the best results in terms of sustainable outcomes, the technology had to be "determinant", "promoter" and "intermediary" (Midden et al., 2007) as described in Section 1.5.2. The attributes of the technology, also mentioned as important by adopters and installers, did not necessarily align with all three of these roles. Specifically, the ability to monitor the performance of the PV panels in real time was usually possible only if the adopter had purchased a wireless monitor, otherwise this information was visible on the inverter, usually sited in a cupboard or loft.

Other results from Transition Streets Totnes case study

This case study provided the only example from all data where a change in circumstances or lifestyle triggered adoption of a new technology. One adopter household stated that they had become involved in TTT specifically because they had recently moved to the street and thought it was a good way to meet people. Their own interests and values had led them to take advantage of the opportunity and were also a factor in their choice to move to Totnes.

4.1.3.4 Case data summary

Collapsing the responses from different roles (Table 4.1.3c) gives a summary of what factors were reported as influential at the different stages of adopting PV panels in the Transition Streets Totnes scheme, presented in Table 4.1.4d. The relative frequency with which factors were mentioned is assigned

Strong, Moderate or Weak, in order to facilitate comparison with other cases with different sample sizes. Overall, it appears that place, technology and user attributes are all perceived to have an influence in shaping the intention to adopt and in adoption of PV panels. The other noticeable pattern is that the importance of place in these first two stages disappears at the use stage. However, it should perhaps be noted that use of the PV panels as a tool to reduce resource consumption was generally not a major concern for adopters anyway.

Table 4.1.3d Summary data for factors affecting the adoption of PV panels in Transition Streets Totnes

	Place	**Technology**	**User**	**Installer**
Intention	12 Moderate	18 Moderate	33 Strong	8 Weak
Adoption	23 Strong	30 Strong	21 Strong	14 Moderate
Use	0 Absent	10 Moderate	18 Moderate	4 Weak

Figure 4.1.3b shows the same data graphically, with the thickness of the horizontal arrows indicating the strength of the reported relationship.

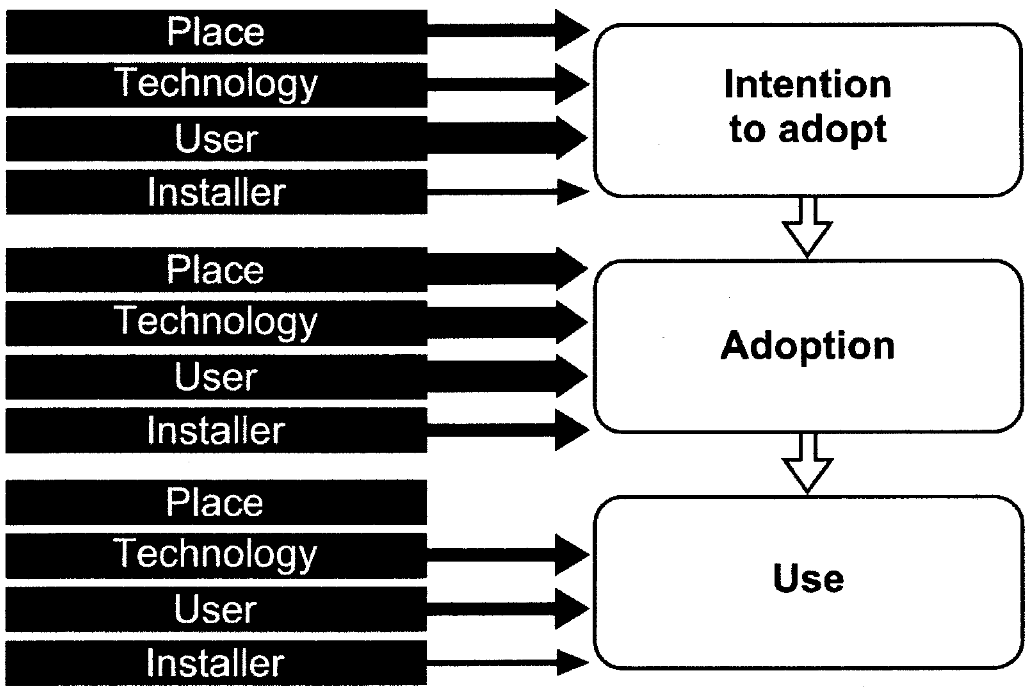

Figure 4.1.3b Illustration of data summary for Transition Streets Totnes

4.1.4 RECharge

4.1.4.1 Summary of case study scheme

Kirklees Council established the RECharge scheme to support the expansion of renewable energy generation in private homes across the council area. This built on a strong cross-party approach in the local authority to find green solutions to a range of issues and to innovate in the role that a local authority could play, particularly through its arms-length agency, Kirklees Energy Services, which became Yorkshire Energy Services (YES). RECharge invited private property owners to apply for free advice and specification of microgeneration for their homes. If a solution was identified, the household could then receive an interest-free loan of up to £10,000 towards the capital purchase and installation costs of the microgeneration. The loan was secured against the property and repayable upon sale of the property. The RECharge scheme ran over three years, spending £3M on 300 renewable energy installations. The majority of installations were PV but the scheme also supported solar thermal, biomass boilers, micro-hydro and air source heat pumps. The context of microgeneration in the UK changed considerably after the scheme inception with the introduction of the Feed-in Tariff (FiT) and the design of the Renewable Heat Incentive. As a result, Kirklees Council now feel that future schemes could be organised very differently without the complications of a second charge.

Table 4.1.4a Characteristics of RECharge

Scheme characteristics	**Comments**
Technology promoted	Renewable microgeneration of heat: biomass boilers, solar thermal, heat pumps. Renewable microgeneration of electricity: PV, micro-hydro, wind.
Interventions	Advised on renewable energy options and then provided an interest-free loan of up to £10,000, secured against the property as a 'second charge' and repayable upon sale of the property.
Desired outcomes / drivers	Removing the barrier of accessing capital finance to increase the uptake of renewable energy in private housing stock (a result of political and policy priorities).

Scheme characteristics	**Comments**
Performance measures	Number of renewable installations. (Note – programme manager suggested externally determined policy measures changed from RE production to carbon reduction at about the time the scheme started.)
Geographic location / settlement description	Kirklees is a unitary local authority in the north of England, centred on the town of Huddersfield but covering a range of urban, semi-urban and rural areas in the north Pennines. Population approx. 401,000 in 171,000 homes.
Scale of funding	£300,000 from local authority funds
Outputs (relevant to research questions)	300 renewable energy installations (PV, ST, micro-hydro, air source heat pump, biomass boiler).
Accountable / lead body	Kirklees Council (Environment Unit) with Yorkshire Energy Services (formerly Kirklees Energy Services).
Partners	Framework installation contractors for a variety of renewable energy technologies.
Contract form for delivery	Yorkshire Energy Services recruited several installers to a framework in order to provide a range of technology expertise. Household advice visits to assess to potential for renewable energy installations were carried out by Yorkshire Energy Services (the vast majority of visits were undertaken by one individual). Legal services to set up property charge were provided by legal team at Kirklees Council.
Start date for delivery	April 2008
Duration of delivery	3 years

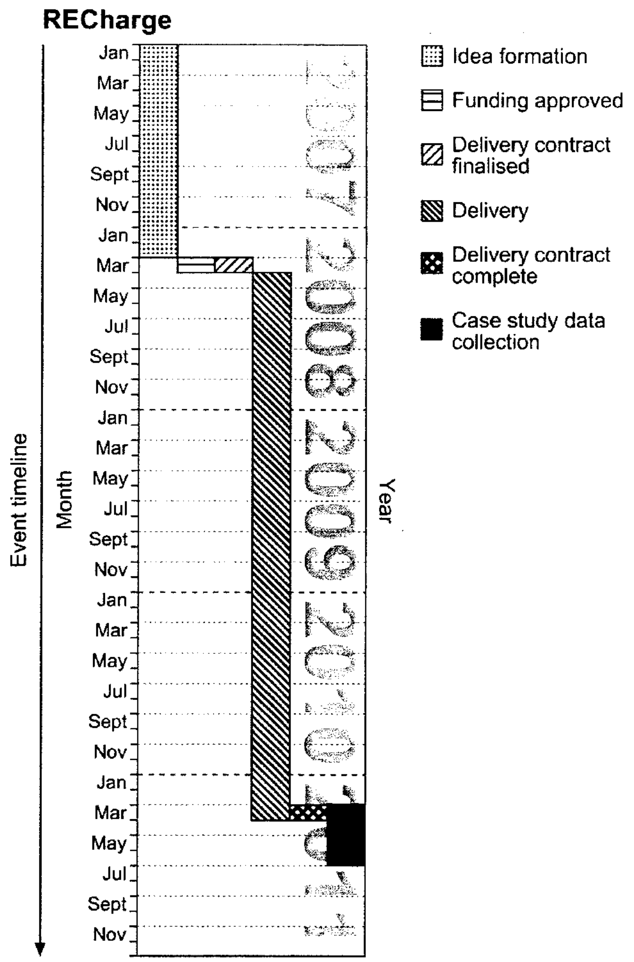

Figure 4.1.4a RECharge event timeline

Table 4.1.4b RECharge event listing

Event / stage	Timing
Idea formation	2007-8
Funding approved	March 2008
Delivery contract finalised	March 2008
Delivery started	April 2008
Delivery contract complete	March 2011
Case study data collection	March – June 2011

4.1.4.2 Case data

Table 4.1.4c summarises the number of times that each of the four sets of attributes (place, technology, user and installer) were mentioned, with the frequency of mentions leading to a categorisation as Absent, Weak, Moderate or Strong. Data is partitioned by interviewees' in Table 4.1.4c, and further detail is provided in Appendix 4.1.D in order to understand the types of attributes referred to.

Table 4.1.4c Factors affecting technology adoption and use identified by different roles

	Attributes	Intention	Adoption / non-adoption	Use
Adopter	Place	15	10	1
N=8	Technology	17	17	16
	User	18	12	4
	Installer	5	12	7
	Other	3	1	-
Non-adopter	Place	3	3	0
N=6	Technology	5	11	0
	User	6	10	0
	Installer	2	6	0
Facilitator / Manager	Place	0	2	0
N= 1	Technology	1	4	0
	User	2	2	0
	Installer	0	1	0
Installer / surveyor	Place	3	11	0
N= 2	Technology	2	9	0
	User	2	5	0
	Installer	1	1	0

4.1.4.3 Commentary on results

Factors affecting intention to adopt

Place factors are identified by adopters, non-adopters and installers as important in developing the intention to adopt green technology. Acquired place factors (the existence of REcharge, local planning and policy) were mentioned but the intrinsic place factors (such as topography), which determined the feasibility of the technology in a particular location, were more influential at the initial stage of considering adoption. These place factors are therefore intertwined with technology attributes and how technology might function in a location in shaping the decision to adopt. The scheme manager made no mention of place factors at the intention to adopt stage, perhaps taking those factors as the given constraints in scheme design and therefore not remarking upon them. Installers did recognise place factors, with a small number of mentions of demography (affluence) and how the history of a location might affect social norms of technology acceptability (the history of mills in the area with the infrastructure of leats or goits).

Adopters and non-adopters also suggested a longer list of possible technology attributes other than those determining feasibility in shaping their interest in adopting the technology mentioning, for example, the comfort that the technology might provide, the disruption that might be caused by installation and the uncertainty of a technology's performance. Once the FiT was introduced, there was some indication that the relative advantage of financial benefit was the primary issue in shaping intention to adopt in some households and that any renewable energy or carbon reduction benefits were irrelevant:

> *"I don't give a monkey's chuff about greenness. I think a lot of this green stuff is a government deployed to impose taxation on people, to be honest."... [later]... "As far as I was concerned, if it made me, £900 a year is what was quoted." [PV Adopter, RECharge]*

Factors affecting adoption

Place factors were identified by adopters and non-adopters as important in adopting green technology. While both acquired place factors (the existence of RECharge, local planning and policy) and intrinsic place factors (property type and age) were recognised, acquired place factors appeared to have a stronger influence at this stage.

The strongest factor arising from this analysis is the role of technology attributes in the decision to adopt. Installers and the scheme manager focussed on those technology attributes that provided relative advantage. Within this, installers focussed on whether the technology would meet the householder's needs. This is typified by the decision on whether to advise on solar thermal or PV installation. If the household did not have children at home and appliances were modern (cold feed dishwashers and washing machines) then the financial benefits of PV were considered more advantageous than the energy bill reductions from solar thermal. Referring to solar thermal systems, one adviser noted:

> *"And quite often I'd have to say 'I'm terribly sorry but it isn't worth your while. I know they're going to give you ten grand to do it, but you'd never use it. You'd have a loan on your house for something that you are not going to use, while you're in the house.' ... 'Really, it's not a go-er for you'. Three kids kicking around, yes, you're going to use all the hot water it can generate every day ... so that's fine. But for some people it's just not worthwhile." [Specifier / Installer, RECharge]*

Some adopters and non-adopters also highlighted the compatibility of the technology, raising concerns over the disruptive effects of installation on the household, issues of boiler sizing, internal redecoration and the heating of attic rooms. The aesthetic value of the technology, particularly with PV, was questioned by a subset of both adopters and non-adopters. A recurring theme from non-adopters related to the (lack of) trialability of renewable microgeneration. They reported that they were fearful of making the wrong decision under pressure or with a deadline and felt there was too much uncertainty in the impact and advantages that the technology might bring. Two non-adopter households said they would keep on thinking about the correct solution for their household, regardless of grant funding.

The impact of the specifier or adviser and of the installer was also clear. All interviewees valued, or believed others to value, the advice offered on technology options through Kirklees Energy Services, with no sales or commission involved. However, when the installation contractor provided cost estimates for installations, several householders noted that these seemed higher than expected and queried the value that Kirklees Energy Services added to justify their management fee which was incorporated in these quotes. A small number of adopters and non-adopters also felt that they could not get the level or certainty of information that they wanted, particularly when their best solution may not be straightforward. A lack of confidence in the advice offered could lead to non-adoption, a challenge recognised by the adviser who undertook nearly all the RECharge advice visits.

> *"It was incredibly frustrating. I mean, the assessor that came round was lovely, really a very nice man. Very helpful. Very personable. But, kind of, with hindsight I think ... we were asking a lot, as well. We were asking everything. About every technology and I don't know if it's unfair but I felt that I would have really appreciated sitting down at that point with somebody or a couple of people that knew a little bit more about*

each of the technologies. I didn't feel like I had enough information to start making any proper decisions. Because then what happened was, the next stage was having people round to look at specific technologies and then it was just so much information that we found it really hard to process." [Non-adopter, RECharge]

"There were one or two things which made it, which kind of slightly put us off, the way it was organised. One was that the person who surveyed the house for putting on the solar panels came from this firm ... that was the only firm we are allowed to use with the RECharge scheme. So the council had made a deal that one company could quote for it. And the man who came round and had a look at first, he was a little bit vague for instance when he looked in the airing cupboard ... he was just slightly vague about whether we'd need to knock the cupboard wall down or alter the position of the bath, in order to fit this new cylinder in. He said, 'Oh, you'll probably fit it in.' But I would have liked him to have come with a tape measure and said, 'Yes, you don't need to alter anything in your bathroom'. Because that slightly concerned me." [Non-adopter, RECharge]

Several adopters and non-adopters also suggested that they believed the advice and support should extend beyond the technical installation to other aspects such as securing planning permission if required and helping with registering for the FiT. Across all technologies, adopters reported a mixed picture in terms of their experience with the installation companies. There was a connection between their view of the council, their view of the installer, and their view of the effectiveness of the technology.

Factors affecting use

The RECharge scheme offered no specific advice before or after installation on changing household practices in order to maximise the benefits of the technology, for example, timing the operation of appliances to use more renewable energy, or managing expectations about technology performance (which was most noticeably an issue for the ASHP installation). Given this aspect of scheme design, it is perhaps unsurprising that in this data the impact of technology in use was only addressed by adopters. Where the impact of technology was discussed by adopters, technology attributes were the main influencing factors they noted. It is worth separating PV from other technologies available through RECharge. PV was described as a "plug and play" [Adviser, RECharge] technology which required no attention from the user and adopter feedback was mainly concerned with the ease or difficulty of completing registration for the Feed-in Tariff. Given the focus on the scheme in reducing financial barriers to RE adoption, rather than in changing related energy behaviours to reduce consumption, it is understandable that no adopters mentioned any changes to their patterns of consumption to take advantage of PV-generated electricity. PV operation was usually invisible to the user, as evidenced by the household whose panels had tripped out and were not operating but the owners did not realise this for several weeks as the PV inverter was in an outhouse. In comparison, other technologies required more action or intervention from the user in order to function and adopters mentioned the issues of getting pellets delivered and having dry storage for biomass; the still-developing designs of new technology for biomass and air source heat pumps; and the user's desire to undertake what maintenance they could rather than be reliant on experts.

Other results from the RECharge case study

The innovative and pilot nature of the scheme, where a second charge against a private property was used as security for a public sector funded loan, meant that the scheme management was complex. It involved several parties including the council's environment, planning and legal services units, an arm's length agency, the private householder and their mortgage lender as well as potentially a separate freeholder and the installation firms. This led to a perceived lack of transparency from adopters and non-adopters:

> *"The first guy came round, assessed your house, everything else, yes that's fine. After that, when it came down to getting the survey done, that took several weeks. It took several weeks after that to get the offer through. And I'm ringing up. Now the girl you ring, is in the council. Yorkshire energy office or whatever it's called. Who then contacts the supplier guy. And it's this triangle of conversations. You eventually get a quotation through, a lot more than the amount. I don't want that...so he says he'll come out again, comes out, another chat through. So this whole process, took, I don't know, month after month after month." [Adopter, RECharge]*

> *"It was not very clear that we went to Kirklees Council but then the Energy Services is branched off. And now he did explain it to us but I don't think it was particularly clear, or whether it was just happening so*

they weren't clear themselves what was going on. It was slightly confusing, who was I actually dealing with? Was I actually dealing with Kirklees Council? Or was I dealing with another company called Energy Services. ... I was slightly surprised to find out that [the installation company] can't supply me that paperwork. It has to go to Energy Services because Energy Services somehow manipulate the numbers. So I don't know what that manipulation means, but they add on their percentage. Now whether it's adding on their legal fee, or whether they're adding on percentage to the actual cost of solution, [I'm] not very clear on. But I was not really happy to hear that they were inflating prices." [Adopter, RECharge]

Householders said they wanted a sole point of contact and evidence that they could trust the judgement of that individual, which meant understanding their adviser's motivations.

4.1.4.4 Case data summary

Collapsing the responses from different roles (Table 4.1.4c) gives a summary of what factors were reported as influential at the different stages of adopting renewable microgeneration through RECharge, presented in Table 4.1.4d. The relative frequency with which factors were mentioned is assigned Strong, Moderate or Weak in order to facilitate comparison with other cases with different sample sizes. The scheme was designed to increase the amount of renewable energy microgeneration installed in private properties and therefore discussion about the use of the technology and its impact was much less than for the prior two stages. User characteristics (both capacity and interests), technology characteristics (feasibility) and place characteristics were are recognised as having an effect on shaping intention to adopt renewable energy microgeneration technology through RECharge. While these three sets of factors were also identified at the decision to adopt, technology attributes, in particular the financial benefits it might bring, became more important at this stage. The influence of the installer, noted at intention to adopt but not as strong as the other three sets of attributes, increased at the adoption stage.

Table 4.1.4d Summary data for factors affecting the adoption of renewable energy microgeneration in RECharge

	Place	Technology	User	Installer
Intention	21 Moderate	25 Moderate	28 Moderate	8 Weak
Adoption	26 Moderate	41 Strong	29 Moderate	20 Moderate
Use	1 Weak	16 Moderate	4 Weak	7 Weak

Figure 4.1.4b shows the same data graphically, with the thickness of the horizontal arrows indicating the strength of the reported relationship.

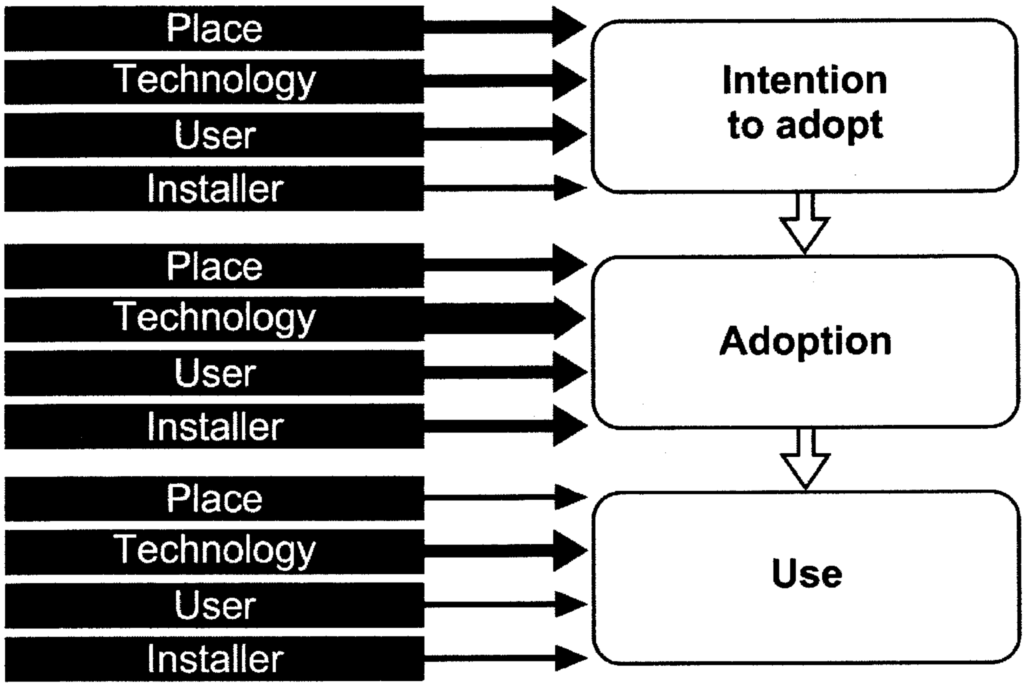

Figure 4.1.4b Illustration of data summary for RECharge

4.1.5 ERYC Affordable Warmth Air Source Heat Pumps

4.1.5.1 Summary of case study scheme

As part of the East Riding of Yorkshire's Affordable Warmth strategy, a project was developed with Regional Development Agency (RDA) funding to offer air source heat pumps (ASHPs) to households without access to mains gas. While the council's main interest was in tackling the health and well-being issues associated with fuel poverty, the funders were interested in identifying routes to carbon reduction in rural areas. Fully funded installations were in the homes of the elderly or those receiving social care. Grants to part-fund ASHP installations were available to other households with some ability to pay. Heating systems were specified by the council's technical team and all installations were carried out by a single contractor who was appointed by the not-for-profit partner company, Community Energy Solutions (CES), through a competitive tendering process.

Table 4.1.5a Characteristics of ERYC ASHPs

Scheme characteristics	**Comments**
Technology promoted	Air source heat pumps.
Interventions	Subsidy, or full cost payment, for installation of air source heat pumps in properties away from mains gas networks.
Desired outcomes / drivers	Reductions in fuel poverty. Improvement in public health through increased comfort. Carbon reduction.
Performance measures	Households supported.
Geographic location / settlement description	Large rural county in northern England with extensive coastline.
Scale of funding	Estimated £250,000 from Regional Development Agency via CES. £50,000 from East Riding of Yorkshire Council (ERYC).
Outputs (relevant to research questions)	More than 80 heat pumps were installed over three years.
Accountable / lead body	East Riding of Yorkshire Council (a unitary authority)
Partners	Affordable Warmth contractor (Atkins plc) Community Energy Solutions CIC

Contract form for delivery	RDA contracted with CES for renewable energy installations in rural areas. CES contracted with ERYC for specifications. CES appointed installers to a framework.
Start date for delivery	April 2007
Duration of delivery	Pilot then 3 years initially, subsequently extended to 4 years, (March 2013) to include Bridlington.

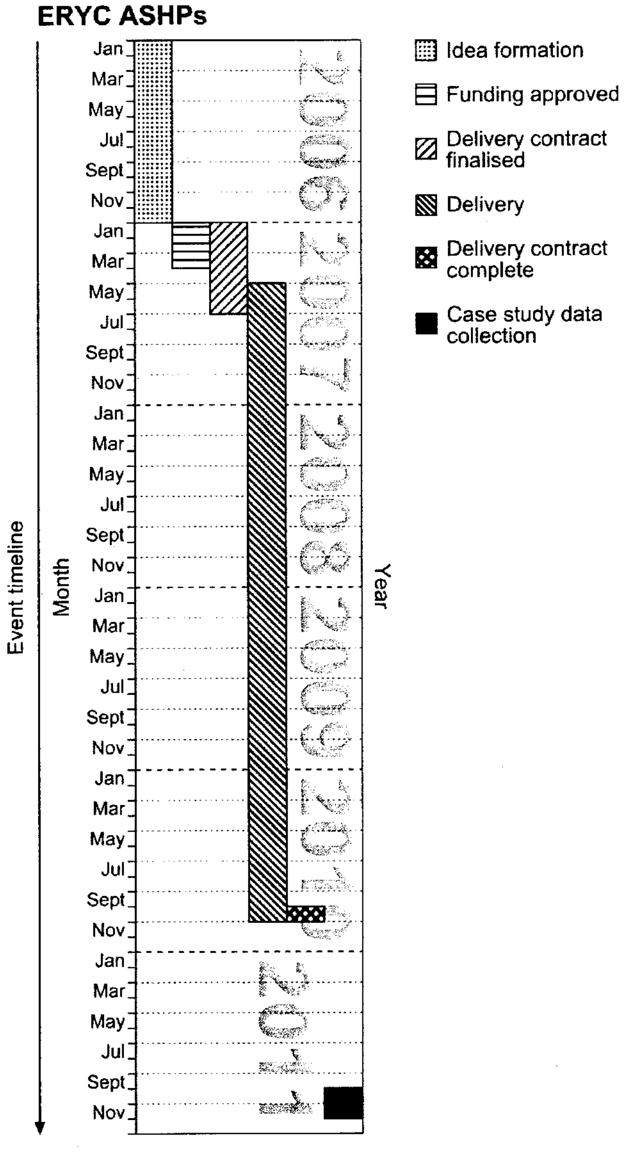

Figure 4.1.5a ERYC ASHPs event timeline

Table 4.1.5b ERYC ASHPs event listing

Event / stage	Timing
Idea formation	ERYC Affordable Warmth Strategy first published 2003 Multiple discussions on ASHPs through 2006
Funding approved	RDA 2007 ERYC match 2007
Delivery contracts finalised	CES framework set up 2007
Delivery started	Nine units installed in postcode YO22, autumn 2007, increased over following 2 years.
Delivery contract complete	RDA-funded project complete in Autumn 2010
Case study data collection	October – November 2011

4.1.5.2 Case data

Table 4.1.5c summarises the number of times that each of the four sets of attributes (place, technology, user and installer) were mentioned, with the frequency of mentions leading to a categorisation as Absent, Weak, Moderate or Strong. This table partitions the data by interviewees' roles and further detail is provided in Appendix 4.1.E in order to understand the types of attributes referred to.

Table 4.1.5c Factors affecting technology adoption and use identified by different roles

	Attributes	Intention	Adoption / non-adoption	Use
Adopter N=6	Place	3	5	0
	Technology	8	5	17
	User	0	13	12
	Installer	1	15	6
Non-adopter	-	No data	No data	No data
Facilitator / Manager N=3	Place	7	10	1
	Technology	4	12	6
	User	7	7	7
	Installer	2	6	5
Installer / surveyor N=2	Place	2	5	1
	Technology	4	8	11
	User	4	1	4
	Installer	5	5	4

4.1.5.3 Commentary on results

Factors affecting intention to adopt

Place factors were not mentioned frequently in shaping intention to adopt, although it was intrinsic place factors (the lack of mains gas and the rural nature of ERYC's area) and sociodemographic factors (the high number of households at risk of fuel poverty in the local authority area) which were critical to the scheme objectives, funding and design.

Looking at the technology attributes which encouraged adopters to consider ASHPs, there are clear links between technology attributes and user attributes. For example, the desire for greater "comfort" was mentioned by three households, all of whom noted that electric storage heaters did not provide warmth when they needed it. Here, comfort is linked to the user attributes of age and activity levels. Because the users were at home for much of the day, the storage heaters had discharged by the evening when the users were more sedentary and needed more warmth.

Factors affecting adoption

Place factors were mentioned more frequently in shaping the decision to adopt, usually in terms of a lack of other options when households felt they had to switch away from current systems, or in terms of the local authority policy providing grant support for ASHPs as a lower carbon form of technology than LPG or oil.

While place was recognised as an influence at the adoption stage, it was still reported as a lesser influence than the characteristics of the technology itself. Adopters were principally interested in the relative advantage that the technology would provide, sometimes a concern for costs and rising costs of fuel, but more often a dissatisfaction with how their current heating systems operated – not providing heat at the right times of day or in a controllable way. Thus the technology attributes of ASHPs were judged in comparison with the attributes of the technology the household currently used. For example, as described above, three of the six adopters stated that their concern with storage heaters was less about cost than the timing and controllability of heat and availability of heat in the evenings as the adopters became more sedentary. One adopter described how, without the financial support, her preference might have been for an oil-fired boiler, a technology she was familiar with:

> *"I mean, whether, whether if the oil heating was going to be the same price or whatever, whether I would have gone for it then, I wouldn't like to say." [Adopter, East Riding]*

The visibility of heating technology also appeared to matter. Two adopters described their preference for the comfort offered by an open fire or flame-effect gas or electric fires. One of the scheme installers described how households were "tempted" to join the Affordable Warmth programme by offering them an electric fire, recognising that this was a feature valued by households.

Adopters recognised that the way they judged the technology and made the decision to adopt was closely connected to their own attributes or user characteristics. Adopters described themselves as too old to learn about new things or unhappy with taking decisions on their own.

> *"I wouldn't do anything really without asking them [adult daughters]. Not when it's costing a lot of money." [Adopter, East Riding]*

The relative attraction of technology features was not static. Changing personal or household circumstances would change a potential adopter's perceptions of a technology. The project manager described an example:

> *"She didn't take it up originally, [Mrs A], because she had a parquet floor in. And that was a big turnoff. And then, subsequently her husband died out of the blue and she had a stroke, and she had a coal fire and so then, she did ... it's weird the way these little triggers ..." [Manager, East Riding]*

The central issues of user characteristics and capabilities are emphasised by programme managers and installers alike. The main barrier to adoption of ASHP was a barrier which applied to the installation of any new system – the disruption and temporary discomfort involved in installation.

> *"Yes, it is a big job, I'm not denying it and I think that's why [Mrs B – a neighbour] didn't go for it like [another neighbour] and I did...But I said to her, well, 'I just wish you had've taken the plunge.' And she said, 'Oh, I don't think I could have stood it.'" [Adopter, East Riding]*

Thus the greater the compatibility of ASHPs with the existing home, the easier adoption would be. However, the technology attributes (specifically the low heat output design of the ASHP requiring new pipework and radiators, and the need for internal storage space for tanks and equipment) mean that

ASHPs are not readily compatible with existing heating systems. As well as the disruption of their installation, ASHPs demanded a degree of change in user habits and routines, specifically in controlling the heating system through adjusting a central thermostat rather than by turning the pump on and off, and a minority of adopters struggled with this.

Factors affecting use

Place played a very limited role in the use of the ASHPs. The only factor noted as affecting impact came from installers. Planning restrictions limited which building elevations the ASHP could be placed alongside and might mean that performance was suboptimal:

> *"We had one property that…there was a step in the front of the building and when I went in to survey that I thought if, this was the early days, if I get that unit sat in there, in that corner, in that alcove, it's going to be in full sun all day long, you know, and they wouldn't let us do it there. It couldn't be on the end elevation and it ended up at the back of the house and it faced north. And when we had our first severe winter, it didn't work. Not properly." [Installer, East Riding]*

It was also noted that the salt-laden air in the coastal situation of many of the ERYC properties meant that fans in the heat pumps might corrode faster in this location than elsewhere although there was no performance data presented to support this.

It is in the case of ASHPs where the technology is not well understood by the adopters that the role of the installer comes to the fore in how the technology is used and the impact that it has. The experience of the installation itself, the information provided by the installer on commissioning and the support available after installation when problems arise were all mentioned as extremely important by adopters and installers. The installers were aware of the uncertainties associated with a still-developing technology. Adopters appeared to use their experience with the installers as a proxy for their satisfaction with the heating system overall. Those who were happy with the ASHP on cost or comfort grounds reported a very positive installation experience:

> *"Were we happy with his work? Well, yes we were. They were the cleanest people I've ever known...I mean, if they made a mess, all they did was hoover it up. With their own Hoover. They didn't use ours. No, as regards workmen, yes, they were brilliant." [Adopter, East Riding]*

> *"But the installation was very good. That's important...Well because they tidied up after them and I thought, you see there's pipes all along there, you can perhaps notice that beam, it's a different shape but I've got used to it now so I don't notice it and they were really, they were really very, very good. Each one of them. All I had to do was to make the tea and sandwiches. So yes I formed quite a nice relationship when they went." [Adopter, East Riding]*

Whereas those who reported a poor experience of installation either did not perceive any benefits from the new system. Or they identified some more negative impacts of the technology (such as loss of storage space, noise impact on neighbours) alongside the benefits of increased comfort.

> *"Same as the oil. No change. No better and no worse." [Adopter, East Riding]*

While installers and scheme managers were concerned about noise, and had had to deal with altering installations in response to neighbour complaints, none of the adopters had a negative perception of the noise of the ASHP installation, although two of them did wonder about the impact on neighbours. One adopter was very positive about the installation's noise when it was operating and described the insecurity she felt when the system fell silent (because it had frozen):

> *"The noise, I find it quite comforting. I love the noise. I do. And I can't explain it but I feel that I am enveloped in like a warm blanket.... I thought that from the very beginning. And I've thought, 'Oh, I know that it's working.' When you hear that, you know everything is working. There was an awful silence when it was frozen outside and I can't tell you ..." [Adopter, East Riding]*

Other results from ERYC's ASHP installations

Technology attributes perhaps explain why the role of the installer in affecting use and impact is emphasised by individuals in all roles interviewed. ASHPs rely on correct levels of anti-freeze in their external systems and in the cold winters of 2009/10 and 2011/12, ERYC adopters experienced many failures with the systems freezing and stopping. Of the six adopters interviewed, four had experienced this sort of failure, had found it distressing and had appreciated the efforts of the council staff as well as the installer in fixing the problems. One, who articulated fears about what would happen in future now that the installer's contract was complete, was clearly anticipating further problems.

4.1.5.4 Case data summary

Collapsing the responses from different roles (Table 4.1.5c) gives a summary of what factors were reported as influential at the different stages of adopting ASHPs under ERYC's Affordable Warmth programme, presented in Table 4.1.5d. The relative frequency with which factors were mentioned is assigned Strong, Moderate or Weak in order to facilitate comparison with other cases with different sample sizes. Place factors intertwined with technology factors in shaping intention to adopt. Once the intention to adopt was formed, adoption was influenced by all sets of factors, with technology attributes, sometimes judged through installer and installation attributes attracting most attention. The unfamiliar technology, this time linked to user and installer attributes, then shaped the perceived effectiveness of the technology when in use.

Table 4.1.5d Summary data for factors affecting the adoption of ASHPS in the East Riding of Yorkshire

	Place	**Technology**	**User**	**Installer**
Intention	12 Weak	16 Moderate	11 Weak	8 Weak
Adoption	20 Moderate	25 Strong	21 Moderate	26 Strong
Use	2 Weak	24 Strong	23 Strong	15 Moderate

Figure 4.1.5b shows the same data graphically, with the thickness of the horizontal arrows indicating the strength of the reported relationship.

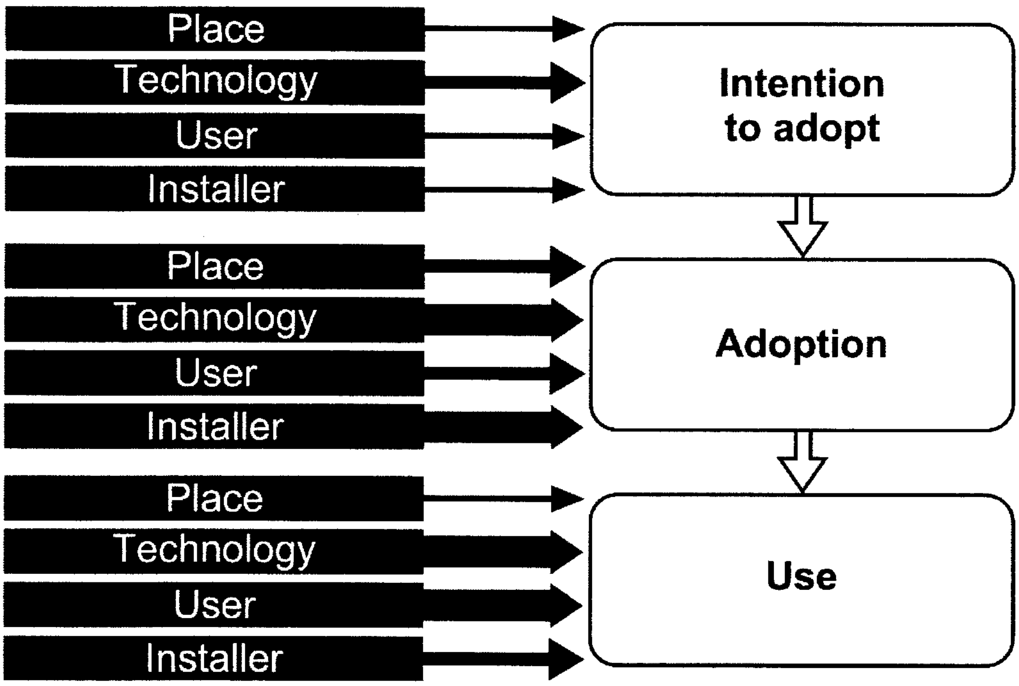

Figure 4.1.5b Illustration of data summary for ERYC ASHPs

4.2 Cross-case analysis

This section looks across all five case studies to find points of similarity and contrast.

4.2.1 How do the answers to the research questions vary across the cases (with increasingly mature technology)?

Table 4.2.1 Stacked case table for strength of influences at different stages

		Intention	Adoption	Use
Place	RE:NEW	[illegible]	[illegible]	Absent
	WarmZone	[illegible]	[illegible]	Absent
	Totnes	[illegible]	Strong	Absent
	RECharge	Moderate	[illegible]	Weak
	ASHPs	Weak	[illegible]	Weak
Technology	RE:NEW	Weak	Strong	Weak
	WarmZone	Weak	Strong	Weak
	Totnes	Moderate	Strong	Moderate
	RECharge	Moderate	Strong	Moderate
	ASHPs	Moderate	Strong	Strong
User	RE:NEW	Moderate	Moderate	Moderate
	WarmZone	Moderate	Weak	Weak
	Totnes	Strong	Strong	Moderate
	RECharge	Moderate	[illegible]	Weak
	ASHPs	Weak	[illegible]	Strong
Installer	RE:NEW	[illegible]	[illegible]	Weak
	WarmZone	Weak	Strong	Weak
	Totnes	Weak	[illegible]	Weak
	RECharge	Weak	[illegible]	Weak
	ASHPs	Weak	Strong	Moderate

Table 4.2.1 stacks the summary tables from the five case studies to give a high level view of the broad types of factors that affect intention, uptake and use. Consistent with the order of the cases in Section 4.1, cases have been stacked in order of the maturity of the technology the scheme was trying to promote.

To reiterate from Sections 3.9 (analysis) and 4.1, the categorisation of the strength of each influence (place, technology, user, installer) at each stage (intention, adoption, use) is not an absolute value, other than in the case of an influence being completely absent. In each case, the number of mentions of influences was recorded (Appendices 4.1A – E and Tables 4.1.1c – 4.1.5c) and the relative frequency of mentions was assessed in order to assign a Strong, Moderate, or Weak influence.

4.2.2 What is the role of place?

The most striking recurring pattern in the summary data is the weakness of place factors in influencing the **use** stage after technology adoption.

In four cases, place plays a moderate role in shaping the **intention to adopt**. The original data shows that this influence is from a mixture of intrinsic, sociodemographic and acquired place factors. The most striking example of sociodemographic data comes from the ERYC and RECharge cases. In the ERYC, the elderly or vulnerable would find any change to their routines disruptive and possibly distressing, and therefore change could not be countenanced. In RECharge, however, the notable sociodemographic characteristic was that the target population, private homeowners, in all but one case were mortgage-free so that they had significant equity to make the property charge viable and low risk for them. All but one of these adopters had no intention to move home in the foreseeable future. This reflects the nature of the scheme design and objectives, although it does coincide with the description of microgeneration early adopters in the UK as predominantly older and living in large detached rural properties (Roy et al., 2008). At the intention to adopt stage, intrinsic place characteristics had a bearing with factors such as the availability of mains gas, the orientation and construction of properties, and land ownership and tenure all mentioned as influential.

Acquired attributes matter in setting up the possibility of adoption (i.e. creating area-based schemes). In the RECharge case, both adopters and non-adopters noted that Kirklees Council was well known for being innovative in environmental matters and that this was important to them:

> *"I think that Kirklees have been one of the most innovative local authorities as regards environmental matters. I think that's been very, very important." [Adopter, RECharge]*

And perhaps more prosaically:

> *"So I suppose we were very fortunate that we came under Kirklees Council. You know, we do slag it off in terms of the poll tax is higher than anywhere else, but there again, fine, we've got this loan scheme. So that is kind of where it triggered off from." [Adopter, RECharge]*

ASHP adopters also expressed gratitude for ERYC's attention to their needs. In Totnes, the degree of pride in living in the birthplace of the Transition Movement and the number of opportunities to get involved in Transition was noted by adopters and non-adopters:

> *"You could go into Transition Town meetings all the time, you could be in the food group, you could be in the renewable energy group. I'm involved with the planters, the Incredible Edible Totnes, and sometimes it just takes me an hour to just go round and water the things if it's my turn, so it could be, you could be involved in so much and you've only got so much time. But it's wonderful, saying that, I know I looked a bit to be overwhelmed on the other hand it's really wonderful that people are there. It creates such a buzz." [Adopter, Totnes]*

In all cases, place factors play at least a moderate role in the decision to **adopt** a new technology. The place factors that matter come from two of the categories in the conceptual framework: acquired place factors and intrinsic characteristics, with little mention of sociodemographic factors at this stage, as the ability to afford to do something had usually already been a filter at the intention to adopt stage. Acquired place factors were mentioned by adopters in all case studies, in particular the availability of support through the area-based scheme, or the underlying local authority policies or local approaches that brought the scheme into existence. The illustrative comment is from Totnes, but similar sentiments were heard in ERYC, RE:NEW and RECharge:

> *"I don't think we'd have done it without the grant. I think that's the other main thing, because five grand's, five grand is cheap for the panels but it's still too much, we couldn't have done it." [Adopter, Totnes]*

Intrinsic characteristics at the adoption stage determine the technical feasibility of many of the technologies. Building type and age, topography and other physical characteristics all appear important here but in this data, they are mentioned more frequently by the installers and facilitators interviewed than by the adopters or non-adopters, suggesting that these factors are influential, but not necessarily visible to the potential adopter, with the installer acting as a kind of filter so that only technically feasible options are considered (see also Section 5.1 below).

There was an interesting pattern suggested in how people described what they valued about where they lived, a specific question within the interview protocol. In RECharge and ERYC, the situation, views and aesthetic of an area were valued:

> *"Well, my wife, when she's driving home on the night, and she goes down the road towards our house, 200 yards she puts the car in neutral and freewheels and looks at the view. That's why we stay here." [Adopter, RECharge]*

Whereas in Totnes, while two households mentioned the situation of the town and its 'prettiness', there were more references to their street and the community in the town, typified by:

> *"...it presented the kind of environment that I would feel happy and safe and enjoy. So, for instance, this road is very typical of the fact that it's a community road. Like the other night, or the other Sunday, we had one of our regular street get-togethers. So there's somebody who has an open house for the afternoon and evening and you drift in and out. There is no separation between our gardens... if I go out into the garden and [M] my next-door neighbour, [A] two doors down, it's always chitchat so it actually harks back to times before, where houses had, you know, nan and aunty and mum and dad and all the offspring, just down the street from, you know, the cousins and uncles and aunts..." [Non-adopter, Totnes]*

The implications of these different forms of place attachment, to landscapes or to communities, are discussed in Section 5.2.2.

The small dataset concerned with micro-hydro electricity generation produced a very interesting example of the different possible influences from locations with the same intrinsic attributes, specifically the availability of water which could be used to generate electricity. A scheme manager described the positive perceptions towards hydropower locally in terms of the cultural heritage of place:

> *"People loved hydro. They could really see it, and I don't know whether that's peculiar because of Kirklees and all the mills around them ran on hydro and there's that residual memory within the populace."*
> *[Manager, WarmZone]*

This was endorsed by both adopter and non-adopter who talked about hydro as part of their reason for selecting specific locations to live in and the strong attraction of a function remembered in the landscape. However, an installer who worked on the RECharge scheme identified a different place factor as the key issue in moving from intention to adoption: affluence, or, as they put it, "*Cash!*" He compared the slow progress in the Pennines with rapid micro-hydro developments in Somerset where a group of mill owners have joined together to share knowledge, covering Bath and the edge of the Cotswolds. This installer noted that West Yorkshire mills were "bought for peanuts in the 1970s by people who wanted to scratch away at self-sufficiency" and that while the Pennine mill owners have seen the value of their properties rise substantially, they rarely have capital reserves in the way the Somerset group do.

4.2.3 What appears to affect the adoption of domestic green technology?

Intention to adopt is formed by a wide range of factors mostly with a weak or moderate influence indicated in this analysis. Adoption of the technology, however, appears dominated by technology attributes. The attributes of installers and the installation process appear to be a stronger influence on the decision to adopt than user or place attributes.

The technology attributes that were appealing to the Totnes programme manager were that PV is modular and standardised so that it was really the only feasible renewable energy option given the funder's requirement that capital expenditure had to be complete in three months from the grant award in December 2009. The Kirklees programme manager also displayed enthusiasm for PV as a "fix and forget" technology which did not require active engagement from the adopter in order to carry out its primary function of generating renewable energy.

TTT stands out as an example where the influence of user attributes on the intention to adopt and adoption is stronger than in other cases. This might reflect the particular nature of the scheme and area, where the 'Transition' agenda was important for people who felt they were part of the community, who were able to articulate the connection between their values and attitudes (and why they self-selected to live in Totnes) and why they chose to install PV.

Once installer/installation attributes were added to the conceptual framework, there were relatively few factors from the dataset that could not be allocated to the four groups of attributes suggested in the conceptual framework. These exceptions are summarised in Table 4.2.2.

Table 4.2.2 Factors from the data which were not classified as Place, Technology, User or Installer/Installation

Description of unclassified factor	**Stage of conceptual framework**	**Influence described**	**Source / case study**
Tomcat (external catalyst for action)	Intention to adopt	Visit from tomcat in the neighbourhood required all carpets and furniture on the ground floor to be replaced!	Adopter RE:NEW
FiT lock-in with existing electricity provider	Use	Limited user interest in engaging with PV as they did not receive any information that might suggests ways of changing behaviour.	Adopter Totnes
Resource institution rules	Adoption	Water meter not permitted for some configurations of property and therefore volume consumption information not available.	Adopter Totnes
Ease / difficulty of application process (an institutional issue rather than an acquired place attribute)	Intention to adopt	Low Carbon Building Programme described as very easy but length of time and number of different partners that had to be included in the more local scheme meant the process was slow and discouraged some applications.	Adopters and non-adopters, RECharge

4.2.4 Patterns observed relating technology maturity to intention, adoption or use

Organising the case study summaries by increasing technology maturity suggests that, for example, place is less of a factor for the most mature and developed technologies and, inversely, the role of the installer becomes more influential with less mature technologies. This reflects the interaction between technology maturity and user characteristics. Less mature technologies require more active engagement from the user in order to be able to function well. Innovators and early adopters are more likely to be willing to do this, with one serial innovator who had adopted solar thermal, PV, an air source heat pump and micro-hydro stating:

> *"All of this is just me with my train set, tinkering." [Adopter, REcharge]*

This contrasts with the situation in the ASHP case study where a novel technology is the best technical option for a group of potentially fuel-poor households who are not connected to the mains gas grid, but the characteristics of that group of users mean they would be more comfortable as late adopters or laggards adopting well-established technologies.

Using the typology of functions proposed for technologies which aim to reduce resource use (see Section 1.5.2, and Midden et al., 2007), most of the green technologies deployed in the case studies are determinant or intermediary as outlined in Table 4.2.3. Note that microgeneration of heat is a determinant technology, directly providing heat to the household, while microgeneration of electricity is an intermediary technology as the household needs to take further action in order to reduce their electricity consumption.

Table 4.2.3 Case study technologies organised by technology role in resource conservation

	Novel / innovative	**Becoming established**	**Well established**
Determinant	ASHP Biomass boiler	Solar thermal	Insulation Easy Measures
Intermediary	Micro-hydro	PV	-
Promoter	-	-	Wireless monitors

4.2.5 How are adoption and use (impact) related?

While no set of factors appears to have a strong influence across all cases, it does appear that user characteristics and technology characteristics can be important in use and impact.

In terms of the user characteristics, individuals across all cases where adopter/non-adopter data was collected emphasised their perceived behavioural control (PBC), often linked to their sociodemographic characteristics such as age and life stage, education or affluence. In Totnes, the Transition backing for the scheme was strongly entwined with the users' involvement and motivation and a description of their own values and behaviours. The three households that had not engaged in any TTT action still described pro-environmental behaviours as important to their sense of identity:

> *"I don't think I spend a great chunk of my time thinking about how I can save resources, my own resources and energy and so on, but I do spend a lot of my time monitoring how I live. I mean that to me is part and parcel of being alive, to be aware of what you're doing, or what I'm doing, right? So that just becomes ... so my resource usage, my way of life, is something that I am aware of, as much as I possibly can be." [Non-adopter, Totnes]*

In looking at the data concerning the influence of technology attributes on use and impact, it is worth separating PV from other technologies as the financial benefits associated with installing PV and registering for the Feed-in Tariff made a significant difference to a potential adopter's economic calculations across the case study period.

4.2.6 The influence of the installer

The role of the installer, while not an observation prompted by the preliminary research questions, emerged as an important theme from the pilot investigation onwards and seems significant enough to warrant discussion. This illustrates how a pragmatic research approach allows for new ideas to extend the research framework originally proposed.

The influence of the installer was observed to be strongest in the decision to adopt where the specific advice offered had a direct impact on the decision taken by the householder. Wrapped up in this set of attributes is also the quality of the installation. In all cases, mention was made of the need for the installer to be personable, to show respect for the householder's home and to work cleanly and efficiently, solving problems rapidly.

In Totnes, the intention to adopt was formed by the peer learning process and the installer's role was simply to assess the suitability of the roof for PV. However, in the REcharge process, without the neighbour connection provided by the Transition Streets approach and where many more technologies were available, the role of the installer was critical. It was remarked upon by adopters and non-adopters as well as by the scheme facilitator, who also described installer experience as one of the criteria used in tender evaluation when selecting a managing agent for the scheme.

Where technologies are less widely adopted and less well understood – in some of the REcharge cases and all the ASHP installations – the influence of the installer and the installation process appears to shift. In these cases, the installer and installation attributes may be taken to be proxies for the attributes of the poorly-understood technology. If the householder does not like or trust the installer, they will be less likely to adopt a technology. Where the householder feels installation has been more messy or disruptive than it should have been, they express dissatisfaction with the technology's performance. This was particularly noticeable with air source heat pumps where the correlation between poor installation or commissioning and dissatisfaction with the technology was mentioned in three out of seven installations across two case study areas.

The implications of these observations are discussed in Sections 5.1.1 and 5.2.1.

4.2.7 Observations of area-based schemes

Figure 4.2.1 compares the timeline of all five cases, centring them on a 'month zero' when funding was agreed. There is no pattern which emerges readily. Each scheme was unique in its timing and funding arrangements. This is not too surprising as cases were selected to provide a range of technologies and little attention was paid to management arrangements when the cases were selected. It is noticeable, however, that all schemes had a long period of discussion and development prior to obtaining funding. TTT had the shortest development period of a year and was the only scheme not driven by local authority officers.

While there are no readily identifiable links to maturity of technology (the timelines are ordered as for the stacked case table, in order of reverse technology maturity) it is possible that technology attributes do influence the delivery model selected. Longer projects are set up by established local authorities, perhaps reflecting that a greater investment of development effort is required and therefore a programme will be designed to run for longer as an attempt to recoup the development investment. In no case does one organisation drive the objectives, offer advice and deliver technology installation. In Totnes, a community group purchases the technology but contracts installation; in London and Kirklees, local authorities contract with not-for-profit management agents who then may contract with technology providers; in ERY, the not-for-profit agency partners with the local authority, funding streams are kept separate and contracts exist from both the local authority and not-for-profit agency with the installation firms. From the scheme descriptions, one aspect of RE:NEW to highlight is the scale of ambition in terms of the properties to be retrofitted across London. The scale and multi-layered governance in London means that the scheme's structure put a lot of levels of decision making and reporting between the overarching goals and the interactions with the householder.

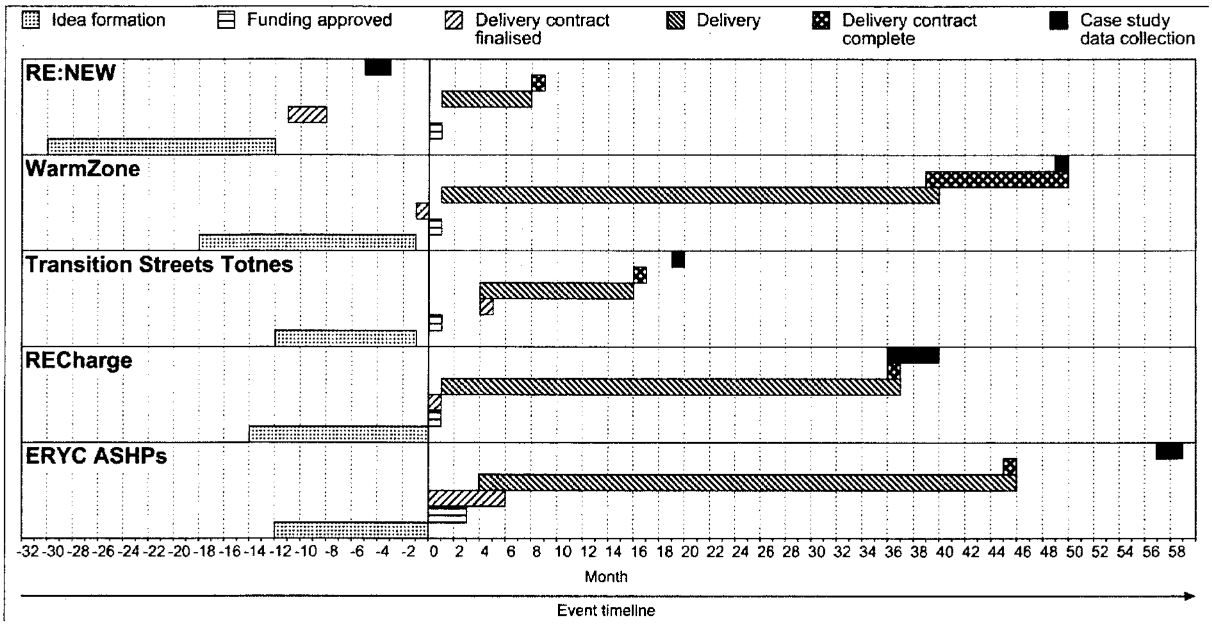

Figure 4.2.1 Timeline summary for all cases

Funding issues came up again and again from scheme facilitators and managers. Funding deadlines drove technology selection, for example, PV was easier to procure in responding to the DECC Carbon Challenge timeline. Budget cycles also drove recruitment, development and retention of skilled staff. One scheme manager described the challenges of trying to match capacity to funded projects in these practical terms:

> *"So even as we sit here now, we have 11 months if the numbers are still the same. It will be another month before anything is decided. Ten months. We will have nine months. Each of those lots, minimum probably, is about 1400 homes per lot. So if I win two lots, I've got the best part of 3000 homes to deliver in nine months. Now by my calculation that's eight Green Doctors. I don't have eight people sat here doing nothing waiting for contracts. Where am I even going to get eight from? In fact, multiply that by 33 London boroughs for, whether it's for British Gas installers or...it's going to be four times ... 130, 140..... Where are we suddenly going to get 140 qualified DEAs [Domestic Energy Assessors] from, like that [clicks fingers]? [Manager, RE:NEW]*

Where bidding was undertaken to try and access specific funds, an area needed to have existing capacity in order to be able to respond to a call. The RE:NEW not-for-profit organisations had full-time development managers actively scouting for such opportunities. The Environment Unit in Kirklees Council in partnership with Yorkshire Energy Services provided capacity to source funding in Kirklees. In Totnes, specific volunteers were identified as the driving force behind bidding. There was more flexibility where funding was being assembled to suit specific purposes (as in the East Riding), although the need to spend money and the financial year budget cycle did drive behaviours and programmes in all cases. Financial or bidding capacity has an institutional component. In Totnes, the existence of a local financial body to assist in providing loans and credit checking, activities that a community-led group could not or did not want to undertake, helped to create a project which could reach households on lower incomes.

Another aspect of the capacity of an area to develop and deliver such schemes is the existence of networks of expertise and knowledge. Area-specific knowledge may take considerable time to build up. One facilitator described how she had been continually involved in working on related projects in the council area for more than 16 years, and it was her local knowledge that guided targeting of the scheme. This illustrates the temporal aspect of area-based learning and how it may be vested in specific individuals.

A further consideration in organising an area-based scheme was the range of partners that need to be involved. There were other aspects of the bureaucracy, entirely necessary from the council's perspective, which led to slow decision making and a need for the potential adopter to be actively engaged in chasing for progress. Kirklees had to involve three of its own departments (the Environmental Unit led the project but the Legal Services Department and the Planning Department both had vital roles) and have agreements in place with YES and the framework contractors. Scheme participants reflected on this in different ways, often pragmatically:

> *"They are of necessity bureaucrats. They have to go through the steps designed by them so that public money is not needlessly embezzled or whatever." [Adopter – RECharge]*

TTT was unusual in the relative simplicity of its arrangements:

> *"Very straightforward... We contacted the woman who was administering it through Transition Town. And said we'd accepted the quote. And were we eligible for a grant? And she got back to us by e-mail and said, 'Yes, your grant is approved.' So it couldn't have been more straightforward...And quite honestly the lack of petty bureaucracy has amazed me." [Adopter, Totnes]*

In all the other cases, the public sector funder or driver required a not-for-profit delivery partner as well as a delivery contractor. Working across these boundaries of expertise and accountability is a challenge discussed further in Section 5.2 'Implications for Practice'.

In RE:NEW, TTT and RECharge, installers mentioned the risks associated with advising the vulnerable or suggesting a technology which doesn't match a household's needs:

> *"From an installer's point of view, what I get a lot, because a lot of the grants are for people in the vulnerable category, is that they put everything on constant and tell the person to control it with the thermostat because they don't want somebody dropping dead on their watch. So they're very fearful of saying, 'Right, if we program it so that*

it actually meets your needs,'... and then it goes wrong, who is responsible?" [Installer, RE:NEW]

The scheme objectives appear to have a bearing on the impact of technology adoption. Given the focus in RECharge in reducing financial barriers to RE adoption, rather than in changing related energy behaviours to reduce consumption, it is perhaps unsurprising that no RECharge adopters mentioned any changes to their patterns of consumption to take advantage of PV-generated electricity. By contrast, TTT PV adopters were more likely to be aware of the potential to increase the benefits of PV by altering their behaviours, and four of the six adopting households reported having made some changes to the timing of running appliances etc. There was less interest in Totnes than in RECharge about the income provided by the FiT. Relative advantage in Totnes focussed on resource reduction and domestic comfort, whereas relative advantage in RECharge had a greater focus on possible income streams. In ERYC, where the scheme motivations were to reduce the vulnerability to fuel poverty and increase the comfort of residents, technology was a means to achieving those ends.

Adopters and non-adopters in all cases commented on the motivations of the installer or adviser. In RECharge, the management fee added to installation costs by Yorkshire Energy Services led to adopters and non-adopters querying value for money of the quote they were given for renewable energy installation. Totnes adopters valued the fact that a trusted group (Transition Town Totnes) handled procurement of the PV panels and that a local firm was providing storage and installation. The ERYC ASHP commercial partners felt that setting up a procurement framework compliant with European purchasing regulations and selecting preferred suppliers on agreed terms and conditions meant they added significant value to the project. In both Kirklees case studies (WarmZone and RECharge) and in RE:NEW, installers felt it was important that they were salaried, not paid on commission, as this made their incentives and motivations clearer. These issues have implications for the design of area-based schemes, discussed in Section 5.2.1 below.

Chapter 5 Discussion

Given the pragmatic philosophy underpinning this research and the concern for consequences or impact of research, it has been difficult to draw a clear distinction between how the research contributes novel aspects to theory and how the research helps, in the light of better theoretical constructions, support the design of more effective practice. However, an attempt is made to differentiate the two with Section 5.1 focussing first on the theoretical implications of the work and Section 5.2 considering how those theoretical modifications might alter the design and implementation of area-based schemes to reduce resource consumption. The limitations of the research are discussed in Section 5.3.

5.1 Contribution to theory

Most of the insights and theoretical developments gleaned from the results described in Chapter 4 focus on the factors affecting the diffusion of green technologies as innovations. These issues are presented first, exploring the role of the installer and installation, and then the role of place and of user attributes that appear to influence how a technology is used once adopted is described.

Before examining these components, it is worth reflecting on the usefulness and effectiveness of the conceptual framework developed for this analysis (see Figure 3.5). It is novel to bring together theoretical areas focussed on people, places and technology for this conceptual framework, and it functioned well in allowing a wider range of factors to be considered for their influence than technology diffusion studies often allow. There are compromises in the framework, notably the lack of feedback loops between peers and over time, and it does rest upon a core of rational choice which, as practice theory shows, does not allow for a full understanding of the processes that are working when individuals make changes to their homes or lifestyles. However, as long as these limitations are fully recognised in the claims made for the analysis, the conceptual framework does appear to allow disparate factors to be considered together, enabling analysis of a more complex socio-technical system than any of the three sets of factors (people, place, technology) could achieve if evaluated separately.

5.1.1 Applying innovation diffusion to adoption and use: revealing the role of the installer

While innovation diffusion theory does recognise that use, and possibly reinvention or discontinuance, are the final stages in the innovation chain, much of the discussion of how attributes of technology and other factors alter innovation diffusion focuses on the rate of innovation adoption. However, as is discussed in Section 2.1.2, while the adoption of a domestic green technology is a necessary stage in achieving reductions in resource use, it is the use of that technology that leads to its impact. Separating the two aspects of adoption and use, as indicated in Figure 3.2, recognises that the rate of adoption and the impact in use may be shaped by different influences, reflecting the differences in those two stages. Innovation adoption behaviour is a discrete action where the one-off action is to 'consume' a green technology, whereas use is a more dynamic process where the on-going actions are to 'consume' what that green technology provides, for example, energy services. It is suggested here that social practice theory provides insights into what shapes user behaviour.

This strengthening of the later stages of the innovation diffusion chain, linking adoption and use, is what reveals the importance of the installer. Change agents in innovation diffusion theory are usually classified as those promoting the technology, rather than the installers who put it in place (Rogers, 2003, pp365-401). The importance of change agents such as the adopter has been highlighted by social practice theorists exploring whether energy consumption can be reprofiled (because reprofiling demand would change the nature of the generation and distribution infrastructure that would be needed and might enable a number of lower carbon solutions) (Strengers, 2012).

The results of this research's pilot investigation suggested an important role for the adviser and installer in shaping the adoption and particularly the use of domestic green technology. This was consistent with the assertion from some practitioner literature that without expert advice, suboptimal decisions will be made by householders (Platt et al., 2011).

The many allusions to the importance of this role in the full dataset were all categorised as 'installer attributes' in the analysis. However, to be able to make more detailed assessments of the theoretical conditions required for both adoption and effective use of domestic green technology, it would be helpful to partition this bundle of attributes into sub-categories in the way that user attributes have been split into PBC, social norms, attitudes, or technology attributes have been divided into relative advantage, compatibility, trialability, observability, complexity, and so on.

A suggested set of subcategories is summarised in Table 5.1.1. These proposals reflect the information from the data in the case studies and are not theoretically constructed and then tested (i.e. the proposed subcategories may not cover all possible impacts of the installer in innovation diffusion, only those impacts which are found in this research's case studies). Aspects of installation are also excluded if they fit in one of the other three sets of attributes: place, technology or users. For example, an evaluation of the UK's Low Carbon Building Programme (LCBP) identified that regional variation in take-up of LCBP grants might be linked to the maturity of the supply chain in particular places (Bergman and Jardine, 2009). The conceptual framework would therefore incorporate maturity of the local supply chain as an acquired place attribute, rather than an installer / installation attribute.

The role of the installer, and the importance of installer attributes, also varies with technology attributes, particularly the visibility of a technology or the degree to which it is understood by a potential user. As mentioned in Section 4.2.2 above, the installer can use their technical capacity to act as a filter so that only technically feasible technology options are considered.

Sometimes these aspects are consciously understood and reported, notably 'installer personal impact' and 'installation aftercare'. Installers and facilitators in WarmZone, and RE:NEW made direct connections between how the adviser or installer presented themselves and whether the householder would be persuaded to adopt the technology. These installers believed that the installer attributes would be used as a proxy for technology attributes in shaping the decision to adopt.

Other aspects, such as 'installer capacity' both 'technical' and 'adaptive', are only expressed implicitly. For example, installers were observed in RE:NEW gathering information on the household before any interactions with the householder. The RECharge and ERYC ASHP specifiers reported similar data collection as part of their work processes. This might be done through assessing a property's attributes in terms of its location and other known installations in close proximity, or on the way to the front door where the installer is looking for signs of life stage (children's toys in the front garden, etc.), assessing the state of repair of the property, whether it appears to be well insulated and so on.

Table 5.1.1 Proposed sub-categories to describe the impacts of installers/installation on the diffusion and use of domestic green technology

Proposed sub-category	**Description**	**Effect and mode of impact**	**Source (example)**	**Links to existing theory**
Installer capacity - technical	Knowledge of the technology function and requirements; skills in specifying, designing and installing effective domestic green technology.	Sets the technical effectiveness of proposed solutions (i.e. the maximum potential benefits from green technology adoption).	REcharge installer and RE:NEW Green Doctors' use of 'decision trees'.	Relative advantage as a technology attribute in influencing rate of adoption in innovation diffusion theory.
Installer capacity - adaptive	How well does the installer gather information about the situation in which technology will be deployed and tailor design and advice to a specific situation?	Enhances the compatibility of the green technology for the adopter.	REcharge installer and RE:NEW Green Doctors' descriptions of information they gather on lifestyles and context.	Compatibility as a technology attribute in influencing the rate of adoption in innovation diffusion theory.

Proposed sub-category	Description	Effect and mode of impact	Source (example)	Links to existing theory
Installer personal impact	The social skills and communication abilities that enable the installer to work effectively with adopters. Demonstrating respect for people's homes.	Influencing the potential adopter's attitudes towards technology and, by association, the pro-environmental behaviours and outcomes that the technology can enable.	WarmZone installer and RE:NEW advisers.	Attitudes as an antecedent for adoption in the Theory of Planned Behaviour.
Installer motivation	Why does the installer advise, design and install? What outcomes do they hope to see from their work?	Sets priorities in design and commissioning. Sets parameters for self-limiting impact.	RE:NEW Green Doctors, RECharge adviser and Transition Town Totnes installers all took decisions on the scope of their advice, based on their own knowledge and interests.	Change agents as one of the "other" factors that influence rate of adoption in innovation diffusion theory.

Proposed sub-category	**Description**	**Effect and mode of impact**	**Source (example)**	**Links to existing theory**
Installation perception	Was installation a positive or negative event from the householder's viewpoint? This includes physical impacts and disruption, information sharing and interactions with the adviser or installer.	Affects householders' perception of the technology and, by association, their perception of the impact of that technology.	ERYC ASHP and Transition Town Totnes adopter data. Also RECharge adopter and non-adopter data on the application process (pre-installation).	Attitudes (as an antecedent for adoption in the Theory of Planned Behaviour) can alter the perceived relative advantage of the technology in innovation diffusion theory.
Installation aftercare	What is the result of the commissioning process? Is there any knowledge transfer or capacity building for the householder? What maintenance and check-ups are required?	Does the adopter understand how they can affect the technology's function? Ensures impact of the technology by checking it is functioning as intended and repairing or upgrading as required.	Transition Town Totnes variation in practices after PV panel installation. ERYC ASHP maintenance issues.	Changing PBC of adopters in the Theory of Planned Behaviour. Might be making a contribution to a type of trialability (technology attribute) in innovation diffusion theory.

The remaining attributes – 'installer motivation' and 'installation perception' – have emerged from the analysis without being explicitly described by participants and appear to be a novel contribution to understanding what affects the take-up and use of domestic green technology. Installer personal capacity and installation perception are distinct, as illustrated by this quote from an adopter who was unhappy with the quality of workmanship in installing her new heating system:

> *"They were nice enough in their self. They were not ... at no stage were they unfriendly or rude or anything. It was just their standard of work which was very poor." [Adopter, East Riding]*

As with the subcategories of attributes for technology, users and place, these different installer/installation attributes are likely to have differing levels of influence at intention to adopt, adoption and use stages. In example from which the quotation above is taken, the installer's personal impact was important in shaping the intention to adopt, but was over-ridden by the installation perception in shaping the adopter's perceptions and use of the technology.

The attribute of 'installer motivation' was linked by scheme managers to the installer capacity, particularly their adaptive capacity. If installers were interested in low carbon outcomes as well as saving energy bills then they would be more likely to gather information and advise on a solution tailored to that household's particular circumstances, combining cost and energy consumption reductions. It is interesting to note that other research has found that even within cohorts of individuals with similar roles and similar institutional and policy contexts, installers' self-perception of impact varies, and correlates with their job satisfaction and their belief in their own expertise (Mahapatra et al., 2011).

However, another aspect of installer motivation was recognised by the installers themselves and seen to be a potentially limiting factor on the positive impact of the installer's work. Two linked dimensions of installer motivation were observed. Firstly, where an installer is very passionate about environmental outcomes, they may take an evangelical approach to the advice they give. Advocating a reduction in energy consumption on moral grounds was not considered to be helpful by other installers who observed this approach used by colleagues. Even though in RE:NEW, RECharge and in Totnes the surveyors/installers owned strong personal commitments to reducing resource consumption and waste, they were careful not to impose this commitment on their clients in an emotive way. Secondly, installers developed their personal views of the boundaries of privacy they would respect in a household. They might (and did, in RE:NEW) limit their advice to direct energy consumption for heating and appliances in the home and deliberately avoid commenting on other energy-consuming behaviours such as travel. They might also decide to respect and not question boundaries in the home set by the householder, speculating that a householder might be embarrassed by untidiness, hoarding or were simply emotionally attached to part of their home which led to preventing the installer from accessing some areas. For these reasons, the adviser / installer's impact is (self) limited. This illustrates that the dominant, post-modern belief in the UK that the customer is always right and that individualism in society cannot be questioned provides some limits to how much change can be achieved. Linked to this, the current UK policy preference is for 'nudge' policies which alter 'choice architecture' in order to influence likely consumer preferences but leave final decisions with individuals (Thaler and Sunstein, 2009). This data suggests that the reliance on individuals may mean that the impact of this 'choice architecture' approach may be limited. If demanding resource consumption reduction targets are to be achieved, this belief may need to be challenged.

5.1.2 Integrating 'place' into innovation diffusion theory

As outlined in Section 2.1.2, innovation diffusion as described by Rogers is widely accepted and consistent with empirical data, but does not routinely have a spatial dimension. Exploration of the spatial aspects of diffusion has focussed on quantitative data and, perhaps, location rather than place. Bringing place factors into the conceptual framework offers some explanation from a theoretical perspective of why the rate of innovation diffusion may vary from place to place. One example is the way in which visible or reported adoption of technologies can change the social norms in a location, creating a new acquired place attribute. This acquired place attribute then shapes the intention to adopt in subsequent adopters, who may feel that the action of adopting green technology is more aligned to, and compatible with, their neighbourhood. Another example is the way in which the physical attributes of place can shape technical feasibility and the adoption decision. As described in Section 4.2.2, some factors may be influential but not visible to potential adopters. Building age and type, local topography and other physical characteristics are mentioned more by installers than by adopters and non-adopters. So potential adopters are reliant on installers using their expertise to filter options and present for adoption only those technologies that will function in that place.

Place attributes do not operate independently of other attributes. To illustrate this, acquired place attributes (such as local policy) influence potential adopters' attitudes in shaping both the intention to adopt domestic green technology and the use of that technology, but a local policy is unlikely to be developed or implemented with vigour if the local population (the potential adopters) do not support the aims of that policy. Using the conceptual framework, in this example, the acquired attributes of place (local authority policy or an area-based scheme) enable adoption through changing individuals' PBC.

5.1.3 Developing a conceptual model of the adopter (and non-adopter)

Innovation diffusion attends to user attributes by partitioning a population into innovator/early adopter/early majority/late majority/laggards using variables concerned with the outlook of the individual, their networks to access information and their attitude to risk. However, looking at the psychological variables which might explain the behaviour of people in those categories helps to illuminate *why* these variables lead to differing behaviours. Synthesising of elements of TPB into the conceptual framework helps nuance the description of the (potential) adopter and leads to a finer focus on why problems arise when some groups are encouraged to adopt some technologies. The ASHP case study makes this case clearly. Here, a novel technology (air source heat pumps with programmable thermostats to give timed output) is clearly the right technical solution for detached properties with no access to mains gas. The people targeted by the scheme are the elderly, infirm or those on low incomes considered in fuel poverty or at risk of being in fuel poverty[7]. It is not that these people are, by preference 'late adopters' that

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[7] The current definition of fuel poverty used in the UK is a household being unable to with sufficient energy services with 10% of the household income (Boardman, 1991). However, it has been proposed that this definition be updated to the number of households and individuals who have required fuel costs above the median level, and, were they to spend that amount, would be left with a residual income below the official poverty line. This reflects that the poorest households may reduce their fuel bills to below 10% of their income by reducing their comfort and not

helps understanding of the issues, although this is a neat description of the mis-match between users and technology. Using the TPB antecedents for shaping intention to adopt, particularly attitude and PBC, helps explain what the underlying problems might be. The users' 'attitude towards the action' is influenced by technology attributes. Is the technology seen to meet their needs and is it comprehensible? Their PBC is influenced by whether they can understand what needs to be done in order to reap the benefits provided by the new technology.

The uncovering of the importance of the six installer/installation attributes described in Section 5.1.1 further adds to the understanding of why problems in technology adoption occur and how they might be overcome. Using this theoretical framework suggests different responses both in terms of design, where control panels might be designed with such users in mind, and in implementation where commissioning and aftercare are particularly important.

A further theoretical contribution signalled by this research, although not fully explored, is the events and experiences that shape potential users' attitudes, social norms and perceived behavioural control. When asked about why they might be interested in environmental issues, respondents often responded by recounting childhood experiences or family culture and occasionally formal education (amongst younger adopters):

> *"But they made do and mend. It wasn't a throwaway society. Which it is now. But not then." [Adopter, East Riding]*
>
> *"When I was at school, I had the most fantastic nature teacher, so we used to go on nature walks every week and bring back all sorts of bits and pieces to draw...And my granddad had a quite a large garden and he had apple trees and I can remember whenever we visited, the first thing was always, 'Granddad show me the garden, show me the garden,' and we used to go up and down the vegetable plots and, you know, so I've always had an interest. And I guess that the thing that really concentrates my mind now is waste because I think, over and above generation of energy by whatever means, I just think as*

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using the amount of fuel required to maintain warmth (Hills, 2012). While both definitions use the need for energy services as their starting point, the proposed new definition focuses on where low incomes and high costs overlap.

> *societies have grown and developed, you know, across the world, we've just been too greedy." [Non-adopter, Totnes]*
>
> *"I've always been interested in the way that humans interact with nature, I guess, so the modules in geography A-level and at university and things, that interested me were 'people and the environment' and 'famine and food security' and things like that so it's just vaguely an interest there, and I guess, yeah, it's just...having read a lot about it, it just naturally interests me and I can't not think about it, do you know what I mean? It seems unnatural not to think about it." [Adopter, Totnes]*

Acknowledging how the antecedents of an intention to act are formed is important as the link to achieving the potential benefits of technology deployment and changing social practice become stronger. This theme has been identified in energy-consumption related case studies of social practice (Gram-Hanssen, 2008) but does not systematically feature in the discussion of innovation diffusion, being wrapped into the bundle of attributes which partition a population between the innovator/adopter/laggard groups.

5.1.4 Technology attributes and the design of area-based interventions

Technologies which can reduce resource consumption and impacts do so in different ways and this research suggests that these modes of operation create another set of innovation attributes not covered by relative advantage, compatibility, trialability, observability and complexity. This was particularly noticeable for energy conservation technologies installed under the RE:NEW programme. In order to be able to analyse the RE:NEW data, the technologies needed to be partitioned again by their function, resulting in the three new analytical 'free nodes' of curtailment, persuasion and efficiency, described in 4.1.1. This reflects the suggestion reported (for firms) that energy efficiency measures tend to be considered together, where in fact they are not a homogenous group of technologies (Fleiter et al., 2011). The three-way partitioning of energy efficiency measures by mode of operation used in this analysis is considerably less complex than the framework proposed to help understand why adoption of energy efficiency measures varies across and between firms (Fleiter et al., 2012).

The additional 'free nodes' in analysis were necessary because the different ways in which the technology achieved resource reduction required different degrees of active participation from adopters in order to realise the potential benefits of the technology. Curtailment technologies required active consent from the homeowner in terms of accepting a limited amount of a resource, for example, low flow showerheads had to be acceptable in terms of perceived flow; heating controls needed to provide comfort at the times when it was needed. Efficiency technologies such as insulation or draft proofing generally delivered their benefits as soon as they were installed with no further requirements from the adopter. Persuasion technologies (wireless displays for electricity consumption and audible shower timers) required the most participation from adopters as the adopters needed to access, interpret and use the information provided if a reduction in resource consumptions was to be achieved. The importance of these different modes also arose as an issue in the Totnes case study. Without either a wireless display for PV panel generation, or a strong user motivation to reduce household energy consumption, the household benefits of reducing energy costs through changing energy consumption behaviours to reflect panel generating performance could not be realised, i.e. a persuasion technology was important in achieving the full benefits of an installation.

The difference between a technology's intended or designed impact and its impact in practice may be described in part by considering the user's perspective of the technology. The type of relative advantage perceived by a household can be related to the role that the technology is playing as far as the user is concerned. The typology of technology functions described in Section 1.5.1 is helpful here: determinant, intermediary, promoter, and amplifier (Midden et al., 2007). A designer or area scheme facilitator may intend the technology to play a determinant role (reducing energy use) but the technology may play an intermediary role (reducing energy bills) for the householder. This means that the cues and controls incorporated in the design of a green technology, perhaps through a LCD control panel on a heating system, may not match user requirements or capacity, perhaps reporting on fuel volume used rather than cost, and the technology may not perform as expected or desired.

Finally, the issue of price as a technology attribute and how it sits within the conceptual model of innovation diffusion merits some further discussion. Other UK research in the adoption and use of low carbon technologies has separated price factors from the other attributes of a technology (Roy et al., 2007). The conceptual framework underpinning this thesis retains price factors as a specific part of relative advantage within Roger's set of technology attributes. It is argued that absolute price or cost is not the important attribute, rather it is the price relative to the resources of the user and the benefit that the user perceives, whether that benefit is directly financial (energy bill savings or FiT income), indirectly financial (increasing property value) or some other kind of return such as an increase in mental well-being through living in a way congruent with the household values.

These theoretical insights open up opportunities for further work and have implications for how such further research is framed. This is discussed in Section 6.4.

5.2 Implications for practice

The pragmatic philosophy that underpins this research's strategy and design includes a 'concern for consequences' (Cherryholmes, 1994) and this Section seeks some ways in which the research can contribute to practice in the development and implementation of area-based schemes to accelerate the effective, beneficial deployment of domestic green technology. This Section starts by examining the practical implications of the aspects of theory discussed in Section 5.1 – the role of the installer and of place – before extending the discussion to aspects of technology design and then how the objectives and performance measures of area-based schemes affect the outcomes achieved.

5.2.1 Role of the installer

The results of this research show that installers offer more than technical advice. With appropriate installer capacity, an installer can unlock the capability of a potential adopter to reap the full rewards and achieve the full potential benefits of a domestic green technology. The first way in which installers can do this is by deploying their technical capacity and adaptive capacity to ensure that the technologies offered to the potential adopter meet their needs. This suggests that effective installers (or installation teams) need knowledge and skills which stretch beyond the immediate technology-related task in hand. As one RE:NEW facilitator highlighted, it may not be feasible for the same individual to hold all the requisite skills and knowledge but a team, taking different aspects of advice, installation, commissioning and aftercare, might be able to cover all the bases. Care would then be needed to ensure that the householder still felt confident of having a direct contact point and real person to talk to, a concern highlighted most clearly in the RECharge case study (see Section 4.1.4). Adopters in RE:NEW, RECharge and ERYC mentioned perceived behavioural control as a limiting factor for them in adopting new domestic green technology; they felt unable to act on their own. This might be because of a perceived lack of information, a concern about levels of risk associated with technology adoption, or a lack of confidence in their own capacity to make the 'right' decision. These limitations could be overcome with empathetic and readily understandable advice from an adviser who was in the home, could see the real context and who could be trusted. This suggests, as mentioned by facilitators and installers in RE:NEW, Totnes, RECharge and WarmZone, that incentivising advisers or installers on the basis of volume of visits can be counterproductive. Potential adopters appear to be more inclined to trust a salaried adviser, not a salesperson, because the potential adopter feels more confident that there is no commission or personal benefit to the adviser from the advice they offer.

The institutional context in which advice is offered also affects the level of risk or innovativeness which an adviser feels able to support. Section 4.2.7 highlighted that installers are aware that, for example, advising an elderly or invalid householder to turn down a heating thermostat might lead to negative health impacts and the installer did not want to be responsible or liable for these impacts. Such judgements will also be affected by the scheme priorities and metrics driven by its objectives, discussed in 5.2.4 below.

The research findings also emphasise the need for quality criteria to be applied to judging the installation process as well as the quantity or capacity of installations. This is because if the adopters do not fully understand the technology, their experiences of the installation process and of interactions with the scheme personnel appear to be taken as proxies for technology performance. This suggests that all individuals who have contact with potential adopters, whether in advice, installation or scheme administration, need to be aware of how their impact and approach forms part of the user's assessment of the technology.

5.2.2 Designing interventions – place issues

The physical attributes of a location will affect how area-based schemes are designed in at least two ways. Firstly, and most obviously, the physical characteristics of a location will determine which examples are technically feasible[8]. Thus if a step change in area resource efficiency is the aim, rather than an objective of deploying a certain number of a particular technology, advisers need to be able to offer a variety of technologies which can be combined in the ways most appropriate to that household in that location. Both RE:NEW and RECharge recognised this, offering a range of technologies for energy conservation through curtailment, efficiency and persuasion in RE:NEW, and a range of microgeneration technologies for renewable heat and electricity in RECharge.

Secondly, the specific form, layout and history of a location may provide particular opportunities or constraints. The case study street in Totnes was a cul de sac without boundaries between back gardens on one side of the road. Residents noted that this enabled them to have active neighbourly relationships both up and down the street and, they thought unusually, across it, due in part to the absence of through traffic. One of the effects of this appeared to be that knowledge and experience could be shared more easily, evidenced by the siting of PV panels on a garage roof when one householder identified the opportunity and two more followed. In effect, the physical form of the area supported development of social networks for information sharing which might accelerate green technology adoption. Such niches provide excellent entry points for area-based scheme managers, giving them a concentrated area of success and increasing the visibility of a technology. However, the niche must not be so distinctive that its experience is not seen as transferable. This was explicitly recognised by the programme manager in ERYC who selected the estate where ASHP installation was to start on the basis that it had a mixed set of existing heating systems so it could be demonstrated that ASHPs were applicable to those who had electric storage, bottled gas, oil or solid fuel heating at present.

The existence of such neighbour knowledge networks (an acquired place attribute) in particular places is not solely dependent on the physical configuration of the neighbourhood, although this may accelerate network development and information sharing. The RE:NEW case study data included discussion of the usefulness of an existing local action group on environmental issues who were willing to undertake the initial approaches to

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[8] For example, PV requires a south facing roof or elevation, micro-hydro requires a drop in water level across the installation, micro-wind requires exposure to steady rather than turbulent air flow.

householders, providing a basis for more rapid adoption of green technologies. The first approaches from local activists were considered more likely to be tailored to local concerns and avoid the perception that the area-based scheme was importing answers and solutions from elsewhere. However, this local connection needed to be weighed against the risk of the local activists taking the kind of moral norm approach which scheme facilitators and installers believed would put off 'ordinary' householders from participating.

Focussing solely on specificity may limit the opportunities to share learning and experiences across different schemes in different areas. An analysis of the differing objectives and achievements of 113 community energy schemes found that while those who are involved in the development of such schemes are well networked, there is less evidence of sharing learning between projects (Hargreaves, 2011b). In this sense, claiming that all locations are different is unhelpful, and looking instead to the ways in which places might have less visible similarities, in their intrinsic, acquired or sociodemographic attributes, may facilitate learning.

Cross-case analysis revealed a strong degree of place attachment, particularly to the visible aspects of an area, the landscape and vistas in the REcharge case, and to the sense of community in Totnes (see Section 4.2.2). This contrasts with findings from questionnaire-based surveys gathering information on how people see their areas and their desire to undertake pro-environmental behaviour (PEB) in Canada. This study did find that self-reported place attachment and PEB were linked but discovered differences depending on the type of place attachment. Natural place attachment consistently predicted pro-environmental behaviour but civic place attachment did not. Participants' comments in these case studies confirm what previous researchers have found: attachment to a physical place or landscape was stronger at a larger spatial scale than social place attachment, which was strongest at the neighbourhood level (Scannell and Gifford, 2010).

5.2.3 Designing interventions – technology issues

The cross-case analysis demonstrated the importance of technology attributes and intrinsic place characteristics at the adoption stage (i.e. in assessing the technical feasibility of a technology). However, separating the intention to adopt from the adoption decision shows that these vital technical factors only come into play once other influences have been brought to bear.

It is worth paying attention to the factors that open the door before worrying about whether the technology will work.

While these case studies were all selected as they involved a behaviour which was adopting some form of technology, differences became apparent in how the nature of a technology is linked to the prompts needed to change behaviour. While some academic literature points to this (Gardner and Stern, 2002), it is largely overlooked or certainly not articulated by the scheme managers and the installers themselves. For example, it has been suggested that the visible demonstration of local technology adoption and commitment or goal setting are effective techniques to encourage the adoption of home energy conservation technologies, whilst increasing convenience prompts greater recycling uptake (Osbaldiston and Schott, 2012). Technology that promotes energy conservation requires different actions to technologies which generate renewable heat or electricity in order to provide all possible benefits to resource consumption reduction. Thus the particular nature of action required by the adopter, and their degree of conscious action including changes to habits and practices, needs to be explicitly recognised in scheme design. For example, the REcharge scheme stopped at the point where a renewable technology was commissioned, although it might have continued its interaction with the technology adopters by providing them with seasonal ideas and tips on how to alter household activities to make the most of the technology[9].

If some form of action is required by the adopter, then it is important that the technology design incorporates feedback mechanisms. This was noted for PV, where the potential of PV to decrease non-renewable consumption is only achieved if householder behaviours change, for example by altering the timing of operation of appliances. For household behaviours to change and benefit to be achieved, there needs to be some visible monitoring of the performance of the PV panels and the real-time energy consumption of the household. This reinforces the findings from early adopters of PV in the UK

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[9] Kirklees Council had deployed this type of approach in another project, funded by the DECC Carbon Challenge, to install PV on privately owned terraced houses in an area of multiple deprivation. The council sent SMS texts to householders reminding them to close curtains to increase thermal insulation, to turn lights off, or to operate appliances during daylight.

(Keirstead, 2007). The RECharge example where an inverter in an outhouse was the only way of discovering if the panels were functioning, and indeed when they failed it took more than a week for that to be noticed, illustrates this point.

The assertion of a need for specificity in scheme design may not seem to sit comfortably alongside the plea made at the end of 5.2.1 above for a wide range of technologies to be available and deployed in response to the context of the adopting household. However, this apparent tension can be resolved through a scheme design which has a process allowing for the possibility of a variety of technology solutions, with advice, installation, commissioning and operation activities which then reflect the particular solutions selected for that household. One of the advisers in RE:NEW hinted at this in describing the "decision tree" process that his team had to follow. Advice offered was contingent on the specific technology deemed most appropriate for that household in that location.

One further dimension is how scheme design aiming to promote green technology needs to be specific in its approach. Scheme managers and those who have to find political and financial support for schemes understandably focus on the relative advantage (financial benefits and carbon reductions) provided by the technology. However, from the user's perspective, the compatibility of a technology with their existing home and lifestyle is paramount. Recognising that the decision to adopt a green technology may be a rational one, but not defined by the quantifiably rational criteria of cost, means including additional aspects of the technology into scheme design. Product designers need to be aware of what makes a technology attractive to users beyond its possible cost-benefit, an issue recognised in industrial design (Bhamra et al., 2011, Roy et al., 2007). Equally, scheme designers need to be aware of what has to be offered to make technology adoption attractive in a particular location, which might mean demonstrating how it fits with the aesthetic of a home or with the way in which people configure their everyday lives. Thus the description offered at the end of the paragraph above might be amended to: "advice offered was contingent on the specific technology deemed most appropriate for that household, **living in that way,** in that location".

5.2.4 Scheme design and objectives - achieving sustainable outcomes

The cross-case analysis demonstrated that the motivations of scheme managers in designing and implementing schemes varied, and included reducing energy use, reducing resource use, reducing energy bills, tackling the risk of fuel poverty, increasing renewable energy generation in an area and prompting more pro-environmental behaviours. Equally, the motivations of adopters and non-adopters varied and included reducing waste, reducing bills and increasing comfort and safety. However, the motivations of funders for these area-based schemes were usually simpler: to reduce energy consumption, reduce water consumption, or increase renewable energy generation. Attempts to weld these differing sets of objectives together seems to lead to performance metrics for the schemes which measured outputs rather than outcomes, such as the number of houses visited rather than the reduction in resource use achieved. This can, in turn, lead to skewing the activities of the scheme, illustrated by TTT's assertion that they would not have promoted solar PV so intensively and might have explored more insulation and bespoke green technology solutions if there had not been the funding constraint to spend capital monies within three months.

Scheme managers sometimes advocated the co-achievement of multiple objectives contributing towards sustainability as part of their scheme design but it was unclear whether this design was instrumentalist or fully integrated. Evaluation of area-based initiatives to reduce energy use extol the additional benefits that a community gains from adopting technology, with possible gains including a community income stream from FiT, greater social cohesion from peer learning and an economic multiplier effect in employment (Platt et al., 2011). The motivation of a scheme does appear to make a difference in what that scheme achieves. An international analysis of the activities of national or regional energy efficiency agencies showed that the motivations, objectives or performance measures, governance and technical capacity of such agencies all needed to be coherent in order for the agency to be successful (Delina, 2012). TTT and ERYC suggest that even an instrumentalist approach to sustainable development (i.e. 'we can achieve our main objective if we also go after these things, which will be funded') does get closer to positive outcomes than pursuing solely the outputs routinely demanded by funders.

5.3 Discussion of limitations

Limitations that were evident at the outset of this research, including positionality, and the strategies developed within the research approach to counter these limitations have been discussed in Section 3.10. There are, however, other limitations which became more evident as the research was carried out and as analysis proceeded. The purpose of this Section is to outline those limitations and discuss their implications. Limitations deriving from the research philosophy, strategy and method are discussed first. This is followed by a discussion of limitations derived from external factors such as policy changes.

5.3.1 Limitations from research design

5.3.1.1 Pragmatism as a research philosophy

While pragmatism is an excellent response to the researcher's desire to direct an enquiry with concern for the consequences of the new knowledge uncovered, the research philosophy also has recognised weaknesses. These include the risk that pragmatism only contributes to incremental change rather than more fundamental or structural change. The bounded nature of this research never countenanced contributing to a structural change, even while the researcher might note that the scale of the challenge posed by sustainable development appears to demand structural change (see Section 1.3.1). Also, pragmatism, by combining the views that perception is reality and scientific fact is reality, finds it difficult to incorporate data which might be categorised as "useful but non-true" or "non-useful but true" beliefs or propositions (Burke Johnson and Onwuegbuzie, 2004). Both of these limitations (taken from a longer list) are pertinent to this thesis. For example, the datasets from adopters included comments on other pro-environmental behaviour they undertook and how these 'catalyst' or 'spillover' activities linked, or did not link, in the adopter's mind. This was "non-useful but true" in seeking responses to the study's research questions. I found it very difficult to ignore these data and indeed, only really managed to reconcile myself to excluding them from this thesis by preparing a separate paper for potential journal submission and highlighting the issue as one needing further research (see Chapter 6 below)!

5.3.1.2 The conceptual framework

The conceptual framework was developed in order to provide a way of organising data concerning the many different aspects of the socio-technical system surrounding the act of adopting domestic green technology. It is therefore a framework which is entirely appropriate to the research questions which are posed. However, the framework's explanatory power is limited because it is static. It does not incorporate feedback loops or interaction between the factors, although the potential for feedback and interaction is noted and surfaces in some of the results, such as a potential adopter's income linking to PBC relative to the technology attribute of capital cost. In addition, the factors which change individual or social norms, particularly the way learning is shared between neighbours and peers in communities, remain unrecognised in the framework because it lacks a temporal dimension. The linear nature of the framework and its lack of dynamic responses to changes in other factors mean that it organises data as it appeared to the interviewee at a single point in time. The dynamic nature of adoption (where conditions change and current non-adopters become adopters, of the original technology or something else) and perhaps more importantly, the dynamic nature of use, where re-invention or discontinuance (see Section 2.1.2) are hinted at in the conceptual framework (see Figure 3.5). Effective data collection exploring this more dynamic framework would require more longitudinal study and analysis.

While it is not a limitation uniquely linked to the static form of the conceptual framework, the difficulty, perhaps impossibility, of describing causal links has to be acknowledged. This data suggests associations of factors under specific conditions. Literature theorises what the causal links might be underpinning these associations, but such links cannot be proved.

5.3.1.3 The different ways in which technologies are perceived by users

A further challenge in using the conceptual framework is the range of dimensions along which perceptions of technology vary. Technology adoption and use might be habitual or discrete, each type of action indicating quite different cognitive processes (Barr et al., 2005). The motivation for technology adoption will also change the influence of different factors, recognised in part by the "attitude" antecedent of intention in the TPB. For example, where the technology provides space heating, it might be a distress purchase triggered by the breakdown of the previous heating system. This will lead potential adopters to use quite different norms and judgements of relative advantage compared to when making planned investments or upgrades in retrofitting their homes. There is also heterogeneity in the types of benefits perceived by potential adopters. Benefits, or relative advantage might be expressed in terms of comfort or finance, or benefits might be linked to a social function, either external, signalling something about the adopter, or internal, reinforcing self-identity in some way. This wide variation in how technology attributes might be framed is difficult to shoehorn into a simple unifying framework. This thesis takes care to acknowledge the simplification and pays careful attention to the presentation of results, ensuring that they are partitioned in such a way that, for example, findings relevant to distress purchases are not also assigned to purchases as part of a planned home renovation.

5.3.1.4 Sample size and case study limitations

The choice was made to explore multiple technologies across multiple locations in order to be able to draw comparisons. However, with limited research resources, a corollary of deciding to explore multiple technologies across multiple locations is that the sample size for interviewees in each role in each scheme was small. As the intention was purposive sampling rather than representative sampling, the risks associated with small numbers of sub-cases appeared small. In fact, interviewees' responses in terms of answering research questions appeared to reach a form of data saturation, with the final interview in each case yielding very little that had not already been mentioned by previous interviewees. Each interview did yield new data, but for later interviews that novelty tended to be in areas outside the core research questions, such as where a potential adopter's interest or lack of interest in environmental issues had arisen.

Case studies, while the appropriate way to organise data for this thesis, are recognised to have limitations, and in particular their "limited generalizability" (Smith and Robbins, 1982) is worth considering here. These five cases describe factors that appear to affect the adoption and use of a variety of domestic green technologies promoted and installed as part of area-based schemes. While the same factors may have some influence outside area-based schemes, that cannot be assumed from this data. In particular, the role of place, and especially the acquired place attributes including local authority policy or programmes, will be less pertinent outside area-based schemes. This limitation on how the research findings can be generalised is acknowledged but considered acceptable and unavoidable, given that this research actively sought the experiences of those involved in area-based schemes, starting from the premise that work at scale, across an area, and creating particular "strategic niches" (Geels, 2005) is important for the more rapid adoption of domestic green technology.

5.3.2 Limitations from factors external to the research method

5.3.2.1 The changing UK policy landscape

As outlined in Section 1.4, domestic green technology can play a significant part in reducing resource consumption in western developed economies. As a result, there is a policy focus on how to accelerate the adoption of such technologies, and this focus, combined with changes in political administration in the UK as well as elsewhere, means that the policy, regulatory, institutional and financial context for green technology adoption changed during the course of this research and continues to do so. This has been particularly noticeable for PV. The introduction of the FiT for microgeneration of renewable electricity in 2010, the rapid uptake of domestic PV and the subsequent reductions in FiT at short notice at the end of 2011, challenged in the courts but implemented in 2012 (and with further changes to come), had a direct influence on potential adopters' decisions to adopt PV. This is reflected in data from the RE:NEW and TTT cases. The introduction of the FiT as a guaranteed, index-linked financial return at a time when interest rates were low meant that the financial benefits of PV became more significant than the environmental benefits for the individual adopter, although the environmental benefits were still the primary motivation for government. The change in policy effectively changed the technology attributes. Interviewees in RE:NEW, WarmZone, RECharge and ERYC also referred to the effects on adoption decision making from the on-going uncertainty about the Green Deal[10] and the Renewable Heat Incentive (RHI)[11]. The specificity of the UK policy landscape means that findings will only apply in other

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[10] Green Deal is the UK government's flagship programme to achieve a step change in the energy efficiency of privately-owned housing stock by supporting economically feasible energy efficiency measures with an interest-free loan repaid through energy bills.

[11] RHI is in some ways analogous to the Feed-in Tariff for heating systems using renewable fuel – biomass and some heat pumps. A premium payment is available to support the installation of such systems.

developed countries under comparable institutional conditions, even if the type of building stock, tenure and patterns of energy use are similar.

5.3.2.2 The dominance of carbon

In the policy landscape, responding to the challenge of climate change is often used as a proxy for moving towards sustainable development. As mentioned in Section 1.3.1, mitigating the future impacts of climate change by reducing greenhouse gas emissions is but one aspect of the need to "live within environmental limits", although undoubtedly it is a visible and pressing aspect. Prioritising climate change over other impacts of resource consumption leads to carbon emissions often being used as a proxy for the levels of resource use. In seeking case studies of area-based schemes which promote technologies to reduce resource consumption, schemes which aimed to reduce energy consumption or carbon emissions dominated the available pool. One of the effects of this dominance of energy and carbon over other resources and impacts is that the original intention to look at domestic resource consumption was narrowed, and even once a field of only energy and water consumption was accepted (Section 1.5.2), the results and findings turned out to have only marginal considerations of water consumption, mainly in the RE:NEW case study. However, if the focus had been allowed to be purely upon energy consumption and carbon emissions, it would have then been too narrow to accommodate the interesting findings from the RE:NEW case study about how water and energy consumption are related from the householder's perspective. An explicit energy-only focus would also have been at greater risk of ignoring the other non-energy socio-technical aspects of household resource use which this thesis wanted to recognise.

Despite the limitations described above, this Chapter has demonstrated that a number of important and interesting findings have emerged from this case study research that contribute to both theory and effective practice. Chapter 6 returns to the guiding research questions and seeks to draw conclusions.

Chapter 6 Conclusions, Recommendations and Further Research

This chapter revisits, briefly, the rationale for this research and the research questions that frame the thesis, as well as the limitations of the research design. This is followed by the main conclusions drawn from the research findings. These conclusions lead to some recommendations for policy and practice in the development of area-based schemes to support green technology adoption. Finally, future research needs highlighted by this research are identified.

6.1 Rationale and research questions

Per capita consumption of non-renewable resources currently exceeds the capacity of the planet to provide such resources. Resource consumption per capita needs to reduce, particularly in the developed world where consumption is highest. Resource consumption in the home is a significant part of total resource consumption, particularly for energy and water. If the impact of resource consumption is a function of the number of people consuming resources, their ability to purchase resources (affluence) and the technology that mediates resource consumption, then changing domestic technology could reduce that impact. The scale of change required is large, and schemes that work on an area basis appears to offer particular opportunities to achieve that scale. Using the language of socio-technical transitions, area-based schemes may provide “niches” in which new technology can develop and then become more visible or useful in the wider socio-technical “landscape” (Rip, 1998). It is therefore helpful to understand what shapes the adoption, use, and impact, of domestic green technology within area-based schemes.

The case studies analysed in this thesis aim to respond to three research questions within the broad area of interest:

Q1: What factors affect the adoption of domestic green technology as promoted in area-based schemes and how does the impact of these factors vary throughout the technology adoption decision-making process?

Q2: What factors shape the use, and therefore impact, of domestic green technology contributing to differences between intended (designed) impacts to reduce resource use and the actual impacts on resource use?

Q3: What is the role of 'place' in the adoption and use of domestic green technology?

Using case studies helps to understand the motivations of domestic green technology users and the way in which factors are intertwined. The research approach, collecting a variety of perspectives within case studies which covered technologies in different stages of a maturity, enabled a nuanced understanding of how and why individual households consider, adopt and use domestic green technology. This approach does not provide robust data on the extent of technology adoption, but that was not the intention of this research enquiry. While an agent-based model or more quantitative approach might have produced more scalable findings in terms of the potential to install green technologies, the mixed method approach sheds more light on how adopting a technology and the impact of a technology in use are linked.

The cases presented in this thesis are all area-based schemes aiming to accelerate the adoption of domestic green technologies. Area-based schemes that aim to promote pro-environmental behaviours without specific technologies will operate in different ways. Equally, care is needed to ensure that one individual adopter's decision making process is not taken to reflect the experiences of all adopters. However, there are some aspects of the factors that affect adoption which are not dependent on being in an area-based scheme. The intrinsic aspects of place will affect the technical feasibility of domestic green technology regardless of whether a household is part of an area-based scheme or not. The existence of an area-based scheme for each of the case studies in effect means that they all have an acquired place attribute in common.

6.2 Conclusions

6.2.1 Case-specific conclusions

Before drawing out five main findings from the case study analysis and discussion, some of the most striking conclusions from the individual case studies are set out in Table 6.1. This table draws on Section 4.1 and helps to identify the basis for the cross-case conclusions that follow in Section 6.2.2.

Table 6.1 Case-specific findings and conclusions

Case study	Finding	Conclusion
RE:NEW	Scheme managers' main concerns were continuity of funding to support local capacity building.	Local capacity is invested in individuals. Lose the individuals (through lack of funding), lose the capacity.
	Installer skill sets beyond technical capacity were extremely important in offering advice that was applicable, acceptable and appropriate.	Installers need to develop interpersonal skills and have a whole-household understanding of resource consumption.
WarmZone Kirklees	Investing considerable resources across a whole local authority area did achieve a step change in the level of technology (insulation) installed.	With coherent objectives, comprehensive partnerships and appropriate resourcing, an area-based scheme can achieve a high level of domestic technology adoption.
	Even here, the scheme managers could not reach approx. 16% of the population.	A proportion of non-adopter households have not considered the technology, and area-based schemes led by local authorities or their partners do not appear to be able to reach these non-considerers, even when all financial barriers to adoption are removed.
Transition Streets Totnes	Participants stated they would not have adopted PV without grant support.	Grant support through an area-based scheme changed perceived behavioural control (PBC).
	Barriers to behavioural change due to user characteristics	User attitudes and knowledge are critical to the impact of technology adoption.

Case study	Finding	Conclusion
RECharge Kirklees	Some participants stated they would not have considered RE installation without grant support and/or clear local authority backing. Potential adopters were heavily reliant on the advice offered by the installer. The scheme objective to increase the amount of renewable energy capacity in private housing stock did not lead to user behaviour change or reductions in energy consumption directly. The complexity of scheme governance created additional barriers for potential adopters (a contrast with the surprise that Transition Streets Totnes participants expressed that their scheme was very straightforward to access).	Local authority support, in terms of finance and clear policy, are both important aspects of area-based schemes, altering PBC. The installer needs to have the capacity to offer advice tailored to the household and household's lifestyle. User motivation and scheme objectives influence the impact of technology adoption. The user experience of interacting with the area-based scheme administration becomes part of the experience of and perceptions of the technology being promoted.
ERYC ASHPs	Where there was a mismatch between adopters' preferred approach to technology and risk and the technology attributes, it appears that the installer and quality of installation become a proxy for the technology performance itself.	Installation processes need to be respectful of adopters' homes, to minimise disruption, and to provide clear information about the process of installation and its impacts. Commissioning and follow-up support are likely to be needed for innovative technologies, and these could be provided by an individual other than the technically expert installer.

6.2.2 Cross-case Conclusions

Adding place factors to the theoretical list of influences on domestic technology adoption and use helps explain the rate and extent of green technology adoption in a particular area.

Place characteristics appear to influence adoption in two ways. Intrinsic place attributes interact with technology attributes to determine feasibility; they provide necessary but not sufficient conditions for adoption. For these case studies, the existence of the area-based scheme is the acquired place attribute that made the difference in achieving technology adoption; acquired place attributes accelerated the process of moving from intention to adoption. Place factors are not reported as important in the use of green technologies. No direct links between intrinsic place factors and adoption were identified; however, intrinsic place factors were reported as affecting an individual's decision to live in a particular location and therefore intrinsic place factors may lead to changing acquired and sociodemographic factors in a particular location.

In Section 2.1.1, it was suggested that strategic 'niches' might be created through area-based schemes designed in response to place characteristics. For example, a large number of solid wall homes in one area might provide the possibility for innovation and development in solid wall insulation. This possibility appears to be borne out by the data from these case studies. The intrinsic place attributes such as housing stock style, or acquired place attributes such as a local culture which supports trialling innovations, provide a distinct local opportunity to install a new technology at a scale that might change local norms. These opportunities only bear fruit when they are accompanied by clear, consistent local policy and action.

Analysing technology adoption and use as a staged process does reflect user experience and provides a framework for different intervention points.

The impact of different factors varies through the process of developing an intention, adoption, and use of domestic green technology. Separating these three steps reflects the staged processes implicit in both innovation diffusion theory and expectancy-value theories of decision making. Adopters, non-adopters and installers all implicitly recognised that these stages were distinct, and sequential.

Place, technology and user characteristics all play different roles at different stages in the adoption of domestic green technology

This research has confirmed that technology attributes, user attributes and place attributes, all suggested from theory, can play a role and are often interdependent. Technology attributes have most influence in shaping the intention to adopt and in adoption. User characteristics are important at all three stages but the types of user characteristics that matter vary between stages, with positive and specific attitudes towards adopting the technology required before the intention to adopt is formed. User motivation, linked to the relative advantage the technology offers, shapes the intention to adopt. The user's perceived behavioural control, which can be changed by area-based support to alter affordability or by providing technical support, is a hurdle to leap before adoption is confirmed. Critically, in the use of the technology after adoption, the user's PBC and attitudes towards the action once again come to the fore.

There is no simple 'recipe' for achieving positive outcomes from an area-based approach to green technology adoption

These five case studies illustrate that there is much greater heterogeneity in the adoption drivers than is often assumed by policy makers. The adoption of PV might have been principally driven by financial motives for part of the research duration, but many other motivations have been described by adopters and non-adopters. These include desires to live greener, to be more resilient, to appear modern or innovative, to fit in with the neighbours, or to be more comfortable. This complexity defies drawing confident conclusions as to the critical success factors for green technology adoption and positive impact.

The variety of motivations is reflected in the variety of threshold criteria applied when a household is deciding whether to adopt a technology. An economic rationale is insufficient to ensure adoption. Technology must also be compatible with the household's current practices. It cannot be assumed that technology will lead to changes in practice. Indeed this research suggests that, if anything, practice leads technology adoption. These findings are therefore pertinent to any green technology adoption, not just technology promoted through area-based schemes. The advantage of promoting green technology through an area-based scheme may be that, by working at scale and in response to several local policy drivers, the social norms and the capacity in the locality may develop so that it becomes more acceptable to change practices and elements of lifestyle.

Equally, the variety of household motivations, attitudes, interests and practices means that the outcomes from technology installation are highly variable. While each household will have a unique combination of these factors which will shape its resource consumption (with or without green technology adoption), again, the benefit of an area-based scheme may be in influencing what is considered normal or acceptable in the area.

Installers and the adopter's experience of the installation process influence how a technology is perceived and used

In these case studies, adopters and non-adopters valued the impartial advice offered by the area-based schemes' selected installers. One of the beneficial aspects offered by the schemes from the adopter's perspective was the provision of advice which could be trusted without an individual needing to go through their own procurement and evaluation processes. Outside an area-based scheme this benefit will not be available, but the role of the installer in providing trusted advice and offering more than technical support to the adopter might still be important.

These case studies also suggest that the impact of the installation experience is important in the use of a technology. Two influencing routes are identified. Firstly, during design, installation and, most importantly, commissioning, the installer can offer information and advice which increases the capability of the householder to use the technology optimally and to change household practices as part of that process. The most striking example was advice on how to change energy use patterns in order to maximise the (financial) benefits from PV, but the same applies for offering advice on water use, and linking that to the energy bills in the RE:NEW project. Secondly, where a technology is unfamiliar, a householder's experience of the installer and installation influences their view of the technology, an effect which was particularly noticeable in the ASHP installations of the East Riding. Increasing the householder's capability to understand and use the technology is important as user attributes, particularly motivation and technical literacy, appeared to be the factors which held most influence over how technology was used and therefore its impact on resource consumption.

6.3 Recommendations

All the recommendations offered below are concerned with the stage on the S-curve describing technology diffusion in a population (Figure 2.3) moving from early adopters to early majority, mainstreaming green technologies in order to reduce resource consumption. This is often the stage at which innovation diffusion stalls, as discussed in Section 2.1.2.

6.3.1 Recommendations for national policy

At national level, local diversity in both methods and outcomes could be recognised and acknowledged.

In the UK, increasing the adoption of domestic green technology continues to be a strand in policy development, particularly in energy policy. The current UK administration has two key domestic energy policies in advanced stages of development and implementation: the Green Deal and the Renewable Heat Incentive. The Green Deal focuses on increasing the energy efficiency of existing housing stock by providing capital funding for cost-effective energy efficiency improvements, paid for through energy bills, coupled with energy company funding for those improvements which do not have a clear economic case to support them (the Energy Company Obligation – ECO). The Renewable Heat Incentive seeks to offer financial support for renewable heat, similar to the FiT for the microgeneration of electricity. The ongoing pressure to increase domestic water metering as a means of reducing water consumption is also applicable here.

However, all the energy schemes are currently national schemes, with national delivery partners and national funding and reporting lines. Some local authorities and partner agencies have been exploring more local delivery and the first Green Deal schemes are area-based (DECC, 2012a), but the principles remain that Green Deal, ECO, RHI and FiT are national schemes which support economically rational technology adoption for carbon reduction.

The findings from this research suggest that the objectives of these four schemes would be better achieved through more local schemes which targeted particularly technologies for particular places, reflecting intrinsic characteristics such as topography and building stock, and also the sociodemographic characteristics of an area which will make householders more or less likely to adopt innovative technologies. Linking funding to reductions in resource consumption achieved on an area basis would enable local agencies to design schemes which responded to the characteristics of local areas and the lifestyles in those areas. This more local approach would also help in developing and retaining local knowledge and capacity in installers, householders and all the partner agencies to continue to reduce resource use in the future rather than simply for the duration of a particular national scheme.

6.3.2 Recommendations for local scheme design

Scheme design should recognise place attributes.

The findings from this research suggest that these national initiatives would benefit from being tailored geographically and targeted where place attributes mean that scheme uptake is likely to be positive. Such place attributes may be physical, such as topography or building stock affecting technology feasibility, or social, such as a householder's ability and desire to adopt technologies. Local policy, including planning policy, is an important acquired place attribute taken by potential adopters as a signal of support from local decision makers. It is therefore important that local schemes are consistent with clearly articulated local policy.

This research suggests that the design of area-based schemes needs to be specific to the place where the scheme is operating, and that they also need to be able to offer a range of technologies that reflect the particular needs and capabilities of that household. Thus the scheme design should promote technologies that achieve particular ends (reducing resource consumption or reducing bills, for example) rather than promoting technologies per se. This might help prevent the adoption of technology simply as signifiers of lifestyle or values without achieving the benefits of reducing resource consumption.

A specific example of where this conceptual framework might be beneficially deployed in the UK at the moment is in the roll-out of universal metering for water supply. Because water supply is managed through regional monopolies, the introduction of universal metering could be considered a form of area-based scheme. While spatial variation of water company action is limited, the findings from this research suggest there might be benefits in dividing the water companies' geographical areas into smaller units that allow for intrinsic, acquired and sociodemographic place factors to be recognised.

Scheme design should not assume that technology adoption assures a reduction in resource consumption.

There is a risk that responding to a household's current habits and needs, while assisting in ensuring adoption, might also lead to lock-in of some current unsustainable behaviours. Technology might enable more sustainable patterns of resource use, but in many cases it does not assure that outcome. It is therefore suggested that area-based schemes need to look more widely than just supporting technology adoption if their aim is to reduce resource consumption. RE:NEW installers suggested that real-time monitors of energy consumption and costs were important in increasing consumer awareness of their energy consuming habits, but these installers also suggested that this impact was only for a limited time and learning did not continue. Post-adoption follow-up support might optimise the use of the installed technology to reflect either lifestyle changes in the household or technology changes such as control system upgrades. Alternatively, the relationship established between installer and householder in discussing technology adoption might be extended through further conversations on other actions that the household might take to reduce resource consumption (i.e. using the technology adoption or assessment as a platform for introducing wider behavioural change) rather than assuming that such catalyst or spillover effects will happen or be positive. This follow-up might be effected through the use of social networks mediated by the original scheme managers to facilitate change at the neighbourhood level.

Scheme design should support installers and assess the installation process.

The success of area-based schemes in achieving the aims of technology adoption, and reducing resource consumption, is dependent on the knowledge and approach of installers and the perceived quality of the installation process. This could be explicitly acknowledged in projects and developing installers' skills could provide further performance measures for projects. The role of the adviser or the installer (often offering or being asked for advice) is worth specific consideration, particularly where technologies are less mature and less understood by householders, illustrated most clearly by the ERYC ASHP case study in this thesis. The installer has to display personal qualities as well as technical ability to ensure that their advice is trusted as well as understood, and therefore acted upon. The installer also needs to be able to identify cues in the home and from the homeowner to identify the most appropriate technology not just for that location but also for the way the household lives.

Table 5.1.1 suggested that four different installer attributes can be identified from these case studies: technical capacity, adaptive capacity, interpersonal skills and motivation. Technical capacity is the focus for professional development in energy and water technology design and installation but the other three attributes might merit further discussion and development by the national trade and professional associations that support installers.

The challenges of measuring real impacts or outcomes rather than the outputs (level of technology adoption) are not to be underestimated, but if the impacts of technology adoption in terms of reduction in resource use consumption were monitored and included as a performance measure for area-based schemes it would drive different support for installers. Installers could be judged by the reduction in resource use achieved rather than the number of households visited or advised, which tends to be the current metric. However, this has implications for project funding and delivery as achieving outcomes is much harder to assure than achieving outputs. The project basis of funding area-based schemes means that many installers are on fixed-term contracts. Delivery agencies face issues of recruitment and skill development anew for each project unless they operate at a scale which allows them to maintain a pool of expertise to draw upon and deploy as different projects arise. This scale of working is difficult to marry with the in-depth knowledge of an area which effective technology installation also needs.

Scheme design should recognise that technology adoption is a staged process.

The factors which influence a non-adopting household to consider adopting a green technology are different to the factors which move that household from intention to adoption. Information about the technology and its feasibility create the intention to adopt, but it is congruence with the potential adopter's priorities and values, and the degree of perceived behavioural control that they have, which confirms the adoption decision. Thus the first stage of an area-based scheme to promote domestic green technology should focus on whether the technology will work and its benefits. Once this hurdle is overcome, the information provided needs to switch to demonstrating that the technology is compatible with the household in physical and cultural ways, and that the household is able to adopt the technology without unacceptable cost. This could be financial cost, but it might equally be a social cost in stepping outside local norms, or a cost in discomfort due to a disruptive installation process. If the first stage of information provision is complete and the potential adopter is persuaded, then failure at the second stage can lead to the potential adopter feeling let down by the managers of the area-based scheme, with negative impacts for further action or for further diffusion among friends and neighbours.

6.4 Further research

Two distinct strands of further research are outlined below. The first strand briefly suggests ways in which the acknowledged limitations of this research might be addressed to improve the robustness of the findings. The second strand considers ways in which the findings from this research might be extended through new research questions.

6.4.1 Overcoming the limitations of this research

Three of the limitations discussed in Section 5.3 might be overcome to some degree by further research which maintains the field of enquiry but modifies the research design. **Larger sample sizes** across more comparable areas could shed light on critical actors, how to change user impacts and the relationship with demography. Exploring these themes through an agent-based model would create opportunities for more **temporally dynamic** analysis, although some of the complexity of the conceptual framework underpinning this thesis might need to be reduced. Another way to explore how technology adoption and use changes over time would be to revisit these five case studies (and their successors, where appropriate), perhaps two to five years after the first interviews, to collect data that describes how embedded the domestic green technology has become and what the impacts of the area-based scheme might be over a longer term. Both the rate and extent of technology adoption, and the local attitudes and norms, could be compared with data from areas which have not had area-based schemes to try and identify whether the impact of the area-based scheme extends beyond a scheme's life. Comparing areas which have had area-based schemes with areas adjacent would also help in identifying any geographical spillover from being close to an area-based scheme.

Comparative analysis with area-based schemes promoting domestic green technology in **other countries outside the developed countries of the West** would test the applicability of the conceptual framework in different cultural and institutional contexts. A challenge here would be in finding a way to adapt the conceptual framework to differentiate between place factors and cultural factors, while recognising that they will also overlap.

6.4.2 Extending the findings from this research

Four distinct areas for further research suggested by the findings in this thesis are suggested. First, this thesis uses 'intention to adopt' as the preliminary stage affected by the attributes of users, technology, place and installers. However, these attributes also describe and influence the **pre-intention** stage. More open data collection from non-adopters who have not even got as far as considering adoption could help shed light on the power of the bias towards the status quo and how these households might be brought into the scope of the conceptual framework developed in this thesis. Such analysis could also draw on more of the issues within behavioural economics and develop answers to research questions that help consider how area-based schemes can reach more non-adopters and what might make them tip into adoption.

The focus on area-based schemes also merits further attention. The ways in which scheme objectives affect the outputs and outcomes from schemes are noted in these five case studies. Research which again used case studies but paid closer attention to how the **structures, capacity and motivation of the individual and organisations affect resource consumption** both during scheme implementation and the on-going impact after scheme completion, could provide insights of immediate relevance to neighbourhood approaches promoting a wide range pro-environmental behaviours.

The powerful **role of the installer** could be explicitly explored in drawing on innovation diffusion and socio-technical systems analysis. This thesis shows that the installer's capacity and practice exert influence over adopter behaviours. The case studies also observed installers respecting boundaries of privacy, and (self) limiting their impact. Collecting more data describing installer perspectives and experiences might create a rich data source to analyse what shapes installer practice and how that might be changed. Research questions might also explore the impact of changing the communication channels used by installers and replacing 'one-to-many' channels with more peer learning and social networks.

Finally, data collected for these case studies has hinted at the possibilities and constraints of **spillover and catalyst effects** from one behaviour, in this case the adoption of domestic green technology, to a range of other pro-environmental behaviours in the domestic energy sphere and more widely, in areas such as travel and food choices. Policy makers often hope that when the changes needed are large, small measures will provide a first step to more significant changes. Participants in this study made little mention of lifecycle effects or rebound effects, but did report a wide variety of other pro-environmental behaviours which might be spillover actions. In some cases, non-adopters appear to be more willing to undertake the more challenging actions to reduce the environmental impact of their lives, compared to adopters who believe that technology has mitigated the impact of their current behaviours and lifestyles. Both adopters and non-adopters report that place factors influence the pro-environmental behaviours that they consider and undertake. A number of further research questions arise, including whether undertaking pro-environmental actions that appear to be 'easy' actually prevent more challenging actions being undertaken, and what local policy or action might support more consistent and positive pro-environmental outcomes.

6.5 Final remarks

In conclusion, this thesis presents an analysis of case studies which supports and extends existing theory describing the adoption, use and impact of domestic green technology. Area-based schemes to promote domestic green technology (and other pro-environmental household actions) appear to be an important route to achieving reductions in domestic resource consumption, but the success of those schemes is heavily reliant on a scheme design which recognised the intrinsic, acquired and sociodemographic characteristics of the scheme's location – its 'place attributes'. Extending theoretical frameworks to recognise these place attributes explicitly would help in explaining why rates of innovation adoption vary spatially. Incorporating place attributes would also assist in understanding why the impact (on resource consumption) of apparently similar levels of technology adoption varies between locations.

The research findings, in particular where place characteristics hold most influence and the critical role of the installer, could help in the design of effective area-based approaches to changing domestic resource consumption through technology. Acquired place factors which assist technology adoption include the existence of a scheme to enable individual householders to act and policies, including planning policy, which support technology adoption, as well as the networks of contacts and knowledge that scheme managers hold, and the local installers' capacity and knowledge. If we are to achieve the scale of change in domestic resource consumption required, we will need to understand not only the technical feasibility of deploying technology, revealed through quantitative research and modelling, but also the socio-technical issues discovered by asking individuals about their personal experiences and views and listening carefully to what they tell us.

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List of Abbreviations

ASHP	Air Source Heat Pump
BME	Black and Minority Ethnic
CCC	Climate Change Committee
CEN	Community Energy Network
CERT	Carbon Emissions Reduction Target
CES	Community Energy Solutions
CIC	Community Interest Company
CFL	Compact Fluorescent Light bulb
CLG	Communities and Local Government
CLUES	Challenging Lock-in through Urban Energy Systems
CO2	Carbon Dioxide
DEA	Domestic Energy Assessor
DECC	Department of Energy and Climate Change
DEFRA	Department for Environment, Food and Rural Affairs
DNO	Distribution Network Operator
ECO	Energy Company Obligation
ERYC	East Riding of Yorkshire Council
EST	Energy Savings Trust
FiT	Feed-in Tariff
GIS	Geographic Information System
GLA	Greater London Authority
GSHP	Ground Source Heat Pump
GT	Green Technology
HEEP	Home Energy Efficiency Pilot
HMO	House of Multiple Occupancy
IMD	Index of Multiple Deprivation

IT	Information Technology
kW	Kilowatt
kWp	Kilowatts peak
LCD	Liquid Crystal Display
LCBP	Low Carbon Buildings Programme
LPG	Liquid Petroleum Gas
MtCO2e	Million tonnes carbon dioxide equivalent
MW	Mega Watt
NGO	Non-Governmental Organisation
OECD	Organisation for Economic Co-operation and Development
PBC	Perceived Behavioural Control
PEB	Pro-Environmental Behaviour
PV	Photovoltaic
RDA	Regional Development Agency
RE	Renewable Energy
RHI	Renewable Heat Incentive
RQ	Research Question
ST	Solar Thermal
TAM	Technology Acceptance Model
TPB	Theory of Planned Behaviour
TRA	Theory of Reasoned Action
TTT	Transition Town Totnes
VBN	Values Beliefs Norms
WI	Women's Institute
YES	Yorkshire Energy Services

Appendix 1
Domestic Green Technologies

The table below lists all the domestic green technologies mentioned by research participants, together with a brief non-technical description of their function.

Technology	**Function**	**Relevant case studies**
Flow restrictors – taps and showerheads	Reduce water consumption	RE:NEW London
Shower timers	Provides visible or audible alert after set duration	RE:NEW London
Wireless energy monitors	Displays real-time energy consumption or cost	RE:NEW London
Draught proofing (doors, windows and chimneys)	Reduces space heating heat losses	RE:NEW London Transition Town Totnes
Hot water tank insulating jacket	Reduces heat losses from hot water	RE:NEW London
Energy efficient gas boiler (condensing boiler)	Improves the efficiency of heat generation	RE:NEW London
Compact fluorescent light bulbs	Reduces electricity demand through increasing efficiency of light production	RE:NEW London Transition Town Totnes
Powerdown switches avoiding standby for appliances	Changes 'standby' mode to 'off' but retains appliance settings when turned back on	RE:NEW London
Reflectors placed behind radiators	Reduces space heating losses	RE:NEW London
Loft insulation	Lagging prevents heat losses through ceilings and roof	RE:NEW London WarmZone Kirklees
Cavity wall insulation	Injects foam into cavity between wall skins, which increases insulation and reduces space heating losses	RE:NEW London WarmZone Kirklees
Photovoltaic panels	Microgeneration of electricity through converting incident sunlight to electrical current	Transition Town Totnes RECharge Kirklees

Solar thermal systems	Microgeneration of heat uses solar radiation to heat water	RECharge Kirklees
Micro-wind turbine	Microgeneration of electricity – wind energy spins a turbine which converts kinetic energy to electrical current	RECharge Kirklees
Micro-hydro turbine	Microgeneration of electricity – water flow spins a turbine which converts kinetic energy to electrical current	RECharge Kirklees
Biomass boilers	Microgeneration of heat through burning biomass (pellets, chip or logs)	RECharge Kirklees
Air source heat pumps	Microgeneration of heat extracting heat from air outside dwelling	RECharge Kirklees ERYC Affordable Warmth
Ground source heat pumps	Microgeneration of heat extracting heat from the ground	RECharge Kirklees

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Appendix 3A
Article for *Green Building* Magazine, Spring 2011

Decisions, decisions

How do real people choose green measures and technology?

There's general agreement that we need to use a lot less resources in buildings. In energy terms, domestic buildings produce one in every eight tonnes of carbon emissions in the UK. That figure gets bigger if you recognise the carbon emissions from generating energy in the first place, and that's not counting the emissions associated with making the construction materials themselves. Alice Owen, University of Leeds, introduces their latest research ...

The UK's ambitious and very necessary targets are to reduce energy consumption by 80%, and we're not going to reach those targets by tweaking 'business as usual'; we're going to have to do things quite differently. We rely on other resources as well of course - water, and many other resources flow through our lives in the shape of food, clothing and other goods.

Advances in technology, and the careful choice of construction materials and techniques all have a role to play in helping us reach much lower levels of resource use. Certain technologies might reduce the amount of resources a building's occupants use, like a grey water system or flow restrictors on taps. Or they might help the buildings occupants use scarce resources more efficiently or even help a building's users generate their own resources, through micro hydro, wind or solar PV. You can probably name many more options, and you probably considered quite a few in deciding what to use in your own projects.

So, how did you decide? From all the choices on offer, how did you put together a package of technologies that would let your project wear the 'green building' tag with pride? Researchers at the University of Leeds would like to learn about how and why you make the choices you make.

It's all about cost

A lot of people say, 'It's all about cost'. Get a decent financial return and it's easy to do the right thing. But evidence suggests that it's not that simple. Time and time again people fail to take actions with a very short payback period, like insulating their loft. Kirklees Council ran a successful scheme providing insulation free to all households in the district, where it was feasible to install it. They visited every home in the local authority area and more than 50,000 homes have had free insulation.

Loft and cavity wall insulation were energy conservation technologies offered for free under the Kirklees WarmZone programme.
Photo: Yorkshire Energy Services

Even though the measures were offered for free, they still encountered pockets of resistance. People thought there must be a catch, or couldn't be bothered with the hassle, or didn't want to take time off work to be at home when the installation took place. And yet there can be a sudden rush to install a technology that has a very, very long payback period maybe because it's visible, or it's promoted really well – remember the buzz of micro wind turbines being supplied through DIY warehouses at the end of 2006? David Cameron was amongst the high profile people who wanted a wind turbine on his roof, although his wasn't one of the DIY warehouse ones. In early 2009, these micro wind turbines were taken off the shelves, in recognition that they didn't deliver enough environmental benefits.

Taking any decision is more complicated than it first appears. Getting the outcome you expect after taking a decision is even more complicated. Installing insulation in homes where the occupiers can't afford their heating bills can increase the energy used. Heating bills are reduced so, understandably, the household turns up the thermostat and takes their benefit in warmth rather than reduced cost. Reduced flow shower heads might be run for longer and water consumption remains at the same level.

Urban or rural – there's green technology to suit

Kirklees isn't the only WarmZone running, although it does have the greatest coverage of homes in its area. In London the RE:NEW programme, a multi-borough project set up by the London Development Agency and Greater London Authority, has a package of insulation and draught proofing measures, combined with a benefits check, which is available across the city (more at www.lda.gov.uk/projects/renew/index.aspx). Unsurprisingly, the technology focus for urban areas is in reducing energy demand through insulation that can fit into the existing building.

In more rural areas, particularly areas which aren't connected to the gas grid, there's growing interest in technologies such as heat pumps; ground source and air source. Air source heat pumps are seen as much easier to fit into existing buildings.

However, not all technologies are appropriate or work effectively at a single-dwelling scale. There are some signs that rural communities are better able to develop community energy schemes. Community owned wind turbines are part of the rural economy in Denmark and several sites across the UK, such as the Dulas valley, have been pioneering a route between the complications of connecting into the grid in the UK (www.ecodyfi.org.uk/pdf/windcs_broddyfi.pdf) channelling some of the income into energy conservation measures for the local community.

The Settle Hydro company has been garlanded with awards. It has installed a 50kW Archimedean screw at a weir on the river Ribble at the edge of this Yorkshire Dales market town, where former mills are part of the landscape: (www.settlehydro.org.uk). Settle Hydro has been generating electricity, when river flows allow, since the end of 2009. Motivations for getting a big project off the ground are varied, but the project team made it clear from the outset that investors were expected to invest in a community asset rather than pursuing a particular financial reward.

Planning, acting, using

It's worth considering what happens at three different stages: planning to act, acting, and using. When you're planning a project, perhaps you select technologies on the basis of what manufacturers tell you about their technical performance, how they fit with the project specification, what your previous experience of the technology was, or what the people you know and trust have told you about it. When it actually comes to purchasing and installing the kit, some slightly different factors come into play. The actual cost benefit and how it fits with the project budget has to be considered. In your particular location, what's the technical performance going to be? And once technology is in a building, users might not operate it exactly as you thought they would. The classic example here is when a building's users want to open the windows to get fresh air and disrupt the carefully engineered closed system heating and cooling system.

Our research is exploring what factors matter most at which stages of planning, acting and using. We divide up the things that might matter into three types of factors:

- Location factors
- People factors
- Technology factors

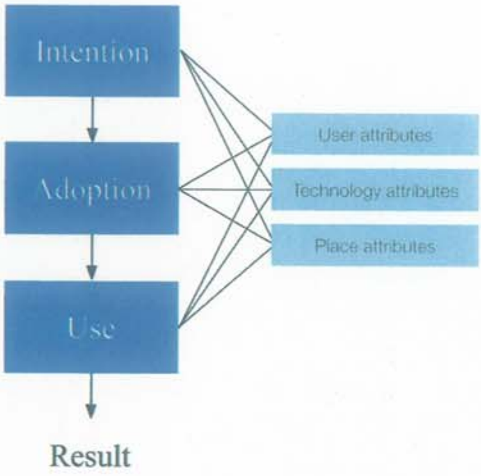

Diagram of 3 stages and three sets of factors.

There's quite a lot already written and used about the people factors, where psychologists and economists are keen to understand why people choose and act as they do. Engineers and economists (again) have also spent a lot of effort looking at how a technology's features affect how well it spreads, so that a given product reaches as much of its potential market as it can. But the other two aspects: location and supply chain, are not thought about as much. The supply chain is often just assumed to organise itself in an efficient way to serve technology, but reality doesn't suggest that's always the case. Our pilot research in Kirklees has suggested that not just the knowledge that a supplier has, but how they present that knowledge is important. Customers are more likely to take the advice of someone who treats their property, and them, with respect and who has a good portfolio of experience to bring to bear. They are more likely to be interested in a technology if they know someone else who has already used the same kit. But if their experience was that a particular technology, like cavity wall insulation, or micro wind, did not work, then it will take a great deal to convince them otherwise, even if the techniques and technology have advanced considerably from their previous experience.

We're particularly interested in how location affects what you decide to do. This might be the physical nature of the location: maybe the opportunity for a large south facing elevation makes PV and passive solar worth thinking about; or a fast running stream or river might prompt

rationale. The logic goes; 'We need to reduce emissions by this amount, so we have to have this number of, say green technologies installed by this point in time to give us a chance of meeting the targets'. But targets set in a 'top down' way, without thinking about what conditions people need seem doomed to failure. To give us some hope of reducing resource use at the scale required, we're going to have to understand how real people make decisions. What information you need, what persuades you that using a technology is a good idea and, crucially, what is likely to work best in different places? In the big projects, like off shore wind farms or centralised carbon capture and storage, there are a small number of, admittedly complex, decisions to be made. But each of the decisions that are taken in each green building project has input from a range of people, with a range of information and putting all those decisions together, so that we get the reductions in resource use that we need - it is really challenging.

you to consider micro hydro. Or it might be that there's a particular style of house or plot size in the area that lends itself to a particular technology, like rainwater harvesting, for example. Or it might simply be that the customers, the people who typically live or want to live in that area, will be enthusiastic about a package of measures which means their homes are greener.

One size will definitely not fit all

Why is this research important? A lot of the time, policy decisions are made on simple economic or technical

Feedback – we like to know what's going on

When 'fit and forget' isn't an option, one of the factors that affects how people take up and use a technology is whether they can get feedback on how the kit is working, together with clear ideas of how they can change what they do to improve the performance of the technology. Smart meters for electricity are an essential part of the UK government's approach to demand management. As you'll know if you've used a smart meter, you can track down all kinds of elements of your electricity bills that you weren't aware of – like appliances with LEDs that mean they have a standby demand. Filling a kettle with only the amount of water you want to boil makes much more sense when there's a visible display blinking 3KW at you while the kettle heats up!

This isn't confined to energy use in the home. The real time fuel use displays in vehicles like the Toyota Prius provide prompts to drivers to change their behaviour, perhaps accelerating less fiercely for example. Changes in driver behaviour improve fuel efficiency alongside the fuel efficient energy technology of the engine.

Alice Owen

Alice and her associates are interested in your views and experiences and are looking for people to take part in telephone interviews. A short on-line survey, which should take about 5 minutes to complete is available at www.surveymonkey.com/s/VBBXS6Z. Alternatively, drop an email to the research team at gyamo@leeds.ac.uk telling us what you think is important in deciding on technology for green buildings.

Alice worked as an engineer in process industries before gaining experience of the sharp end of environmental policy in local government. Alice was the UK Sustainable Development Commissioner leading on issues including planning, until 2011. She now combines PhD research on green technology at the University of Leeds with work at Arup on sustainability.

Appendix 3B
Interview Guide

Interview structure – adopters and non adopters

Not from interview: Postcode and intrinsic place characteristics

Possibly not from interview but from other data sources? Resource consumption (volume and cost) before and after GT installation

Prior to interview:

Introductory statement – name and area of research

Establishing rapport, testing recording equipment

Permission to record, permission to use data

Don't answer any questions you don't wish to

Ask interviewee to confirm name and adopter/non adopter etc

Information sought	**Response type / range**	**Purpose**
Location, type, age of property, how long lived there, garden, orientation of roof	Location: postcode Type: detached/(bungalow)/semi/ terrace/flat Age of property: Length of residence: <1yr, 1-5yrs, 5-9yrs, >9yrs Garden: Y/N Roof: n/a , N, S, E, W Council tax band	Acquired place characteristics GT feasibility
Age, gender, type of employment, income (of householder and household), number in household	Use coded response cards? Age: <25, 26-34, etc. Type of employment: Income band: Number in household	Sociodemographic characteristics

Information sought	Response type / range	Purpose
Knowledge of technologies What, If anything, would you say was "green technology"? Why is it green?	Look for e.g. Solar, PV, GSHP, wood fires, CFL, Hippos, composters Modes of resource impact: curtailment, efficiency, substitution, feedback	Interviewees starting point w.r.t green technology What is expected impact of deploying GT?
Knowledge of resource consumption	Describe different types of resources? Any benchmarks of 'acceptable' resource use?	Relevance of knowledge on resource issues to GT adoption?
Knowledge / perceptions of local authority activity	Any perceived data on acquired characteristics of place	Relevance of knowledge about local authority policy to GT adoption
"How would you describe the area where you live?" "Is your street typical of the area" "Is your house typical of your street?" "Is there anything special about where you live?"	Perceptions of local area	Perceptions of place.
What do you think of if I ask you to describe the place where you live? How big is it – where does it start and where does it end?	Perception of place spatial extent -	Is Local Authority the place-unit or is it some other area?

Questions for adopters

How did you come to have [the GT] installed? What happened? How did you hear about it? Who did you speak to?	Who are effective intermediaries? Social networks – place based, or not? What triggers the intention to adopt?

Who advised you? When?	(look for Ajzen's perceived capability, subjective norms, initial attitudes
Did it seem like a good idea straight away? Why (not)?	What were the conscious factors in describing 'relative advantage' Look for learning
What's it been like, using [the GT]? Can you describe how the GT fits in with your day?	Seek to identify any cultural/practice constraints or drivers of resource use GT attributes: ease of use Ease of maintenance
Do you think you'd ever get [another GT] installed? If yes, what would you do differently this time?	Look for the factors that affect spillover, or learning

Questions – for non adopters

Did you know that [other people on your street] have got [GT] installed? Have you thought about getting [the GT]? Why don't you have [the GT]	Is GT observable? Awareness – how local are social norms? Perceptions of [the GT] Perceptions of self- capability
What improvements would you like to make to you home?	What is valuable to potential adopters?
[If rejection happened after some initial exploration] Can you tell me about why you started to explore getting [GT] and what happened? What triggered your interest? Where did information come from? What happened? Why did you decide it wasn't for you?	
Are you considering any other GT?	

Adopters/non adopters final questions

Personal values (might need to be later in interview once trust established) What's most important to you in living the kind of life you want to live here?	Family / community/ affluence/ environment global / environment local/.....	Subjective norms – self-identified beliefs
Pro-environmental actions?	e.g. recycling, NGO membership,	Relevance of attitudes for behaviours (with pro-environmental actions taken as an indicator of attitudes)
How long do you see yourself staying here? (in this house, in this area)	Length of time	Indicators of attachment to place and/or acceptability of different payback periods.

Would it be OK to contact you again, as the analysis proceeds, to follow up any points or check anything?

What to offer in terms of feedback / thanks for time / what happens next?

Appendix 3C
Ethical Approval Information

Appendix 3D
Example Transcript

150311 Kirklees Recharge non adopter

2000-2030 Telephone interview

Interviewer : You'll hear the click of me turning on the machine, the digital recorder button. So the process here, Mrs [A], is that having explained a bit about the research, I'm going to just ask you to tell me the story of, of your particular experience with green technology and then, if there's time, I'd like to ask you just a few questions about your household and your home, so that I can understand the context that you're in. Is that okay?

I hope I can answer them.

Interviewer : Well if there is anything that you don't want to answer that's absolutely fine. And if there's anything that you can't answer, that's fine too!

My husband is in the kitchen and he's ready to take over if I can't.

Interviewer : If you want to pass me on that absolutely fine. So let's start off with what happened. The notes I got are that you were interested in, oh I haven't even got what the technology is, but you must at some point decided to, oh yes its biomass, so can you tell me about what prompted you to think about a biomass boiler for your property?

No idea. You'll have to leave that one for my husband to come in. I don't know why we did that. I've no idea. I don't know the answer to that at all.

Interviewer : fair enough. Okay. Were you aware of the RECharge scheme? How did the link with the RECharge scheme come about? Do you know?

No, I'm sorry, I don't. My husband will remember it all.

Interviewer : Do you want to pass me over or...

Well you carry on with your questions because we can come back to that.

Interviewer : Okay, so what's, if once you were thinking, you were looking at changing your energy supply.

Yes. Somebody came to the house.

Interviewer : Right. Somebody from the council? Or somebody from out of the blue or what was it ...?

Well, obviously we knew he was coming. He had an appointment to come. And this chap came and looked and, you know, we discussed things.

Interviewer: Was that Trevor Mitchell? It ages ago now you may not remember the name but does that ring any bells?

No, that doesn't. It probably was, I don't know. He was a very nice chap anyway, whoever it was that came.

Interviewer : Okay and he talked to you about what kind of things?

About what the options were and we decided which was the one that we thought was the best.

Interviewer : Right. Which was?

Was it a pellet thing?

Interviewer : Right. A pellet thing. And can you recall why that was was the thing that seemed to be the best option for you?

Oh dear. No.

Interviewer : it's not meant to be a test!

Well, you see obviously my husband's got more idea, I just go along with what he says, you know.

Interviewer : Fair enough.

And he thought it was the best option.

Interviewer : Right. And, so then following that, what somebody else came out did they, to...

I don't remember anybody else coming out. I think we had an estimate, which my husband thought was over the top and he said no way am I paying that, although you will only pay it when you sell the house. He wasn't having any. He said no. And that was really the end of it. And I think he got back to, to this chap who'd come in the first place, and he said "oh, they must have made a mistake." It seems very high, you know, the estimate. And it just sort of petered out from there. And we ordered a wood burner, I think it came through the Internet, and it's been fitted in and it's wonderful.

Interviewer : Is that a stove or or a stove from the boiler?

It's, you know, a wood burning stove. You can burn coal on it is well.

Interviewer : right. And you're happy with that?

Oh yes. Well the other one sounded good because you could program it. I mean obviously you can't program this. If you don't light it, obviously there's no heat and stuff. But it's very, very good. Very good.

Interviewer : Right. And does it make any difference to, obviously it makes a difference to your comfort, you're enjoying being warmer, has it made a difference to any of your energy bills or anything like that, do you know?

I don't think so.

Interviewer : But that wasn't the issue view particularly. You wanted the ...

I wanted, I personally wanted to be warm before we had this boiler in we just had an open fire, well I mean obviously, my husband wasn't coming home from work until about 5:30, lighting the fire, it takes a good hour or so to get the house reasonable before we put the pump on to warm upstairs. I mean it was, it was all right, we couldn't afford to run it all day. Oh it would be tremendous the bills. Probably it is a bit cheaper because during the very cold weather we did have it alight all day. We haven't been doing lately because it's been nowhere near as cold, is it?

Interviewer: no. No.

But during that very cold weather it was alight all day.

Interviewer : Right. Okay. So you've definitely got some benefits in terms of the comfort, which is good. Okay. So it wasn't, it wasn't the energy bills that would driving you per se or particularly?

No.

Interviewer: Is there any other kind of home improvements and other comfort things that you've been thinking about, or you are thinking about?

No. Well I'm not, no. We're wanting to have a few windows changing, you know. They're bloody old things. They need changing. And that'll make a difference. But no, nothing other than that that I am aware of, no.

Interviewer: again, changing windows you probably will get a bit warmer won't you, but you want to change them because their old rather than because you want to, I don't know, stop the drafts or something.

Well it would help both, wouldn't it?

Interviewer : Right. Okay. I'm just wondering if either is more important to you when you're working out what to, from the endless list of things that you can always do around a property, working out what comes to the top of the list.

Yes. That is the top of the list, or it's the top of my list at the moment. For next winter, you know! For winter yes, the next winter.

Interviewer : Yes, assuming we've seen the end of this one. You have to hope don't you? I'm just going to ask you a little bit about your property if that's okay? I've got the postcode as HD5 0PY. And what kind of property is it? Is it detached, semi?

No unfortunately it's a semi. It's a very old property. Must be 200 years old at least. All the walls are all horse hair and, between, you know two layers of ... there's this horse hair in it. It is, it's a very old, well a couple of hundred years old, I would imagine. That's half of the property. Half the property's this old house. When we had a family we built a new house onto it to make it bigger.

Interviewer : Oh, I see. Right. And now somebody else lives in that one?

No. It's still the one house. There's a house next door, I'm going round in circles now, the house when we bought it was four rooms and the house next door is four rooms. Since we've had the children, we've had to build on to make room for them.

Interviewer : Right. Right. I'm with you. So it sounds as if you've been there quite a while?

Yes. About 39 years, I think.

Interviewer : Excellent. So it's grown with you? And your family.

Yes

Interviewer : so you've extended and therefore you've done quite a few changes over that time I guess?

Yes.

Interviewer : And do you have a garden?

Yes.

Interviewer : you do. Okay. Now this is a question that usually people can't answer so I'll be quite impressed if you can. You don't happen to know which direction the orientation of the house is, which way the roof faces, do you?

No. We get the early morning sun in the back but the heat of the day comes in at the front does that give you any idea?

Interviewer :. So that would be so back faces east?

Does it?

Interviewer : the sun rises in the east, yeah, so does that mean that your roof, so the sun falls on the slope of the roof at the back of the house in the morning?

Yes.

Interviewer : okay that's great. So in terms of the area where you live, if you've been there 39 years you'll know it very, very well. How would you describe the area where you live?

In what way, what you mean?

Interviewer : Well if somebody said says. "oh, what's it like where you live?" What do you say?

Well, it's very quiet. Not many houses where I live.

Interviewer : Would you say it's rural?

Oh yes. We're surrounded by fields .

Interviewer : But you've got neighbours there, you're in a little…

There's 5 houses where I live.

Interviewer : Right. Okay. That is your house is typical of that little cluster, that little hamlet?

Yes I suppose it is. Yes.

Interviewer : And would you say there is anything, would you say there's anything special about it? There may be something that has kept you there that long, is there anything that you think is special about the area and anything that makes it…

I just like it, you know. Like the openness of it. We're not overlooked. For one thing. People leave you alone for another. It's just, I just like it. My husband is here if you want to get back to the first few questions, he'll be able to tell you all about it.

Interviewer : Is that okay with you?

That's fine.

Interviewer : thank you ever so much. [Mrs sweet calls Mr sweet to come to the phone he asks if it is a nice young lady and she says yes!]

Hello.

Interviewer: hello, Mr Sweet. Thank you for talking to me. My name is Alice Owen and I'm a researcher at the University of Leeds. I don't know what if anything your wife's relayed from our brief conversation this morning or what you've picked up from the council, but I'm looking at the practical issues that people have about taking green technology, and we'll come back to what that might be, into their homes and how they use it. Okay? And also, you should know, your wife agreed that it was okay for me to record the conversation. Are you okay if I carry on recording our chat briefly? Hello?

Hello?

Interviewer : Hello, sorry, can you hear me, or am I a bit faint? Are you okay if I record our conversation?

Yes, yes.

Interviewer : That's great. Thank you. So what I started off by asking was how you'd come to even think about the biomass boiler, the pellet system which was what initially you had contact with Kirklees about. What was it that made you think about that?

Well, our open fire we used to have was a bit inadequate. We needed to update it a bit. And we was going to go for a multifuel stove. You know. Anyway, there was the grant going, the scheme about the green things, so we got that chap to come from Huddersfield, I don't know his name, but he came from the Huddersfield office, the surveyor, he came along and we had a chat with him and he said, 'yes, sure, the best thing you could have really is a pellet boiler.' And he explained it to us and he said, 'I'll have to go away and find out which one will suit you'. So he did that. And he came back with this pictures of this pellet boiler and we liked it and it would do what we wanted and we showed him where we wanted it fitting which would mean a little bit of structural work. It was going to go in where the old range used to be years ago in our old kitchen. Because it's a very old house this. About 1700 and odd, I think. And it used to have a range, you know, obviously, in the old kitchen, so we wanted it putting in there but it would mean lifting the lintel a bit for the height of the thing to go in. But he said that's no problem, they can see to all that. So he said I'll go back to the office now and tell you, tell, what will happen is that we'll get on to the firm that's installing these things, they'll send somebody along to assess what's to do and all that. And we'll go from there. Nothing happened.

Interviewer: oh.

And then an estimate came through the post from this firm for about 12 1/2 thousand pounds for fitting this pellet boiler in an outhouse.

Interviewer: Right. So they. So how. Two things. First of all how long did that whole process take? How long did it take between there's a guy coming out to chat to you about your options and coming back and then the quote? Because you said nothing happened and then it magically appeared. Was it weeks or months?

It would be a bit, yeah. Was it long, [A]? Can you remember how long after when a chap came before the estimate came through? No we can't remember. I think it was a bit, you know, probably getting a bit anxious. So anyway this estimate came through and we looked at it and we thought well, that's not right. Has nobody been here. Nobody has come near the place from this firm. Yet here's this estimates telling us we're going to have this thing fitted in an outhouse for 12 1/2 thousand pounds. So I rang this Huddersfield office again and she said, 'oh, well he's in the area. I'll get onto him." And he called in actually that afternoon. I showed in the estimates. In fact, I think he took it away with them. As soon as he looked at it, he said, "oh, there's something wrong here." Obviously they've got the house mixed up or something. They haven't even been. They should have been to see it. He said, 'so I'll go back to the office and we'll get onto them and they'll be in touch'. Well, of course, nothing happened again, did it? Meanwhile the time is ticking on and we got fed up with waiting so we just went out and bought this stove and fitted it ourselves because, you know, winter was coming on obviously and we wanted to get the thing done. We bought this one and we are very pleased with it.

Interviewer: excellent. So one of the problems for you was it just took too long basically, you needed to be warm before winter and it wasn't going to happen.

Yeah, it took too long and the fact was, I think they was trying to rip us off, that first firm. And I think that estimate their sent through, they sent it through on the off chance because the money was coming from the council, the council was going to pay it and it would come out of the house eventually when it was sold and that was the principle, so they probably thought, 'ah, well they won't bother". You know, they're not paying for it out of their pocket now, they're not bothered, but when you think about it 12 1/2 thousand pounds for a pellet boiler fitted and we didn't even know what was to do, you know, the building work that we said would need doing they didn't even come to see that so, this surveyor chap said, "Yeah there's definitely something wrong. They must've sent it for the wrong house or something." But nothing happened.

Interviewer : oh dear. Because the building work is an issue. If your house is 1700 and something, is it listed?

No, it's not listed, no.

Interviewer: Right. Okay. Because I imagine that you probably ... building work isn't straightforward in a property of that age, is it? You know, things like raising a lintel and the like?

No, not really. It's an old, olde-type stone house.

Interviewer : So you , fairly straightforwardly, you know, you wanted to replace your open hearth. Did you have an open hearth with a back boiler on it?

Yes, we did. We had a high output back boiler, but it wasn't quite adequate because we've extended the house a few years ago, added a long extension and .. oh, [A] says she's told you. So this boiler wasn't actually up to it at that stage, it wasn't getting the water hot enough, so we knew we'd have to update to something powerfuller. That's what brought that on.

Interviewer: so sometimes people are looking to change their systems because of the price of their electricity bills or their heating bills. But for you, you wanted a system that worked rather than necessarily trying to reduce the cost of it?

No. Because this thing really burns the same sort of fuels. Pretty much. So not a lot of difference there.

Interviewer: I've just got a couple more questions. That's really helpful and really clear and it points out ...some of the fundamental problems that you experienced.

They got kicked out I think, didn't they? That first firm. Don't you know what they were called, I can't remember. But the actual firm that was fitting them in them early days....

Interviewer : they did change some of the contractors halfway through, yeah, there was ... I don't know the names of all of them, there was somebody called Blue Flag who...

Oh, that might have been it.

Interviewer: maybe?

I think possibly. It rings a bell anyway. Possibly.

Interviewer: this is going to sound like a bit of an odd question given your driver was mainly you wanted to be warm, which is fair enough, but does the term 'green technology' mean anything to you? What do you think of if you say, "what's green technology?"

Well, it's obviously something that doesn't put any sort of harmful emissions out. And that's what, these pellet boilers aren't supposed to do, are they? Well this thing we've got now, it doesn't... well it does a bit, I suppose, it burns smokeless fuel which I suppose is reasonably... and the logs are mostly logs which we've felled ourselves from the garden. Ash and stuff. So it's not really ... I don't know whether you class that as green. Probably not as green as your pellet boiler but...

interviewer: I'm just interested in what you think about the term really. I have to be honest I couldn't tell you whether it is better or worse or indifferent but ... so is there anything else that springs to mind at all if you were asked what is green technology?

Well, it's like, it's something like solar panels, isn't it? You're not putting any emissions out, but you're making use of the sun and things like that. And the wind things. You are not causing any harmful things that you're harnessing the wind power, that's green energy.

Interviewer: last few questions about your kind of attitudes, and what's important to you. Do you do anything that you consider to be green or environmental ? Or is that not just something that you interested in?

Well, I don't suppose we do really.

Interviewer : That's absolutely fine... I'm curious, don't worry , it's not a test.

I drive a car. That's not green, is it? You know things like that. We're just normal people. No.

Interviewer : Okay that's great. How many people, is it just the two of you now.

Three of us in the house at the moment. We got our youngest son still living here at the moment.

Interviewer : would you mind telling me how old he is just so I can…

He's 22.

Interviewer: a fine upstanding young man no doubt!

He is!

Interviewer : And are you in work?

No, I packed up the year before last. I'm retired. I'll be 67 in July so I'm an old fogey now.

Interviewer : You don't sound it, I have to say. Anyway… and do you see yourself staying in the property for a while yet?

Oh yes. We'll be here until we're carried out in a box. We've only been here forty-odd years so far, so we might as well finish it off.

Interviewer : And my final question which may sound a bit random but is to do with how people get information, which is do you have access to the Internet at home?

Well. I don't personally because I don't know how to use one, but our Andrew, the lad that lives here, he's got one and he does that all for me. If I want anything, he's straight up on the computer and gets it on, what you call it, eBay and stuff like that. Yes.

Interviewer: that's interesting. Is that how you found the stove that you've got it now?

It came from the computer, yes. Did it come from eBay, did it, Andrew? It did. He says it did. It did come off eBay.

Interviewer : Brilliant. Well I hope you got yourself a bargain and it certainly sounds you've got something that meets the needs which is brilliant.

They're lovely things. I don't know what you've got at home that but they're lovely things really. They make a bit of mess of course, but you sit round them at night, you know, when they're glowing away and they're lovely things.

Interviewer: Yeah, we do have a wood burner and it's going in the other room at the minute and it is lovely. But we haven't got the back boiler on it like you have.

You've got the dry one. We're thinking of fitting one of those next door, in the house, my daughter's living in there at the moment. They've only got an electric three bar fire which is no good, so we're thinking of getting one of these. Because they're not expensive are they, the dry ones?

Interviewer: No, well, not ... I mean, you still got to pay your other fuel bills, for your electric heating up the rooms and the like but I didn't think it is too bad for the comfort and just for how nice they make the home. Each to their own, isn't it?

It is. The system was already in. The radiators, that was another thing when we originally went for this pellet boiler, it was going to be coupled into our existing system so that wasn't to all put in, it was all in, all the radiators and the piping and everything.

interviewer: Right. So it wouldn't have been that... the only building work would have been actually around the boiler unit itself?

Yes, just to make the height where the range used to go, it was like a big open fireplace, it would be about 4 foot, 4 1/2 foot high, and that wouldn't be enough for that boiler so the actual lintel across and the bottom of the chimney breast would have to be lifted a couple of foot. That was the structural work. That was all that was involved. And then somehow connecting it into our system works anyway they said 12 1/2 thousand pounds.

Interviewer: so that was the end of that.

In an outhouse which we haven't got.

Interviewer: It was a bit of a problem then.

Well, obviously they hadn't... they just sent that estimate off pat, I think. Nobody had been here from that company or anything.

Interviewer: Well you can't do something like that without a visit, can you?

As soon as that surveyor spotted it from Huddersfield, he said no that's all wrong. They should have been up and seen it.

Interviewer: one of the things about the pellet boilers that sometimes people say is the problem, is the getting hold of the pellets and storing them. But if you're ready storing your logs and that for the stove, you've got that ...that didn't seem like a problem

No. He told us it wasn't a problem. He said there's plenty of outlets now that do them, so we were quite happy with that. We don't know now, because obviously we haven't gone down that route so we don't know, but he said it was easy to get. I suppose as they get more popular obviously there will be more of them.

Interviewer: so it sounds in summary like your contact with the guy who came out from the Huddersfield office was positive and constructive.

Oh yes he was a nice man.

Interviewer: But then the process is just kind of didn't do anything that you were expecting it to.

Yeah, I think it was the installers that let it down.

Interviewer: that's really helpful. Mr [A] thank you very much indeed

You're welcome.

Interviewer: and thanks also to your wife for both fielding the call morning and for talking to me earlier on, that was very helpful. What happens now is I put your experience, the good and bad and why you went for what you did, into the mix. I'm talking to about 20 people across Kirklees and I'm talking to people in four different areas like Kirklees and that all goes forward.

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Appendix 3E
Sample from NVivo Casebook

Filename	Area	Role	House-hold size	Property type	Property age	Internet access	Tech 1	Tech 2	Position	Education	Working?	Length of residence	Source type	H2O meter ?	Planning status	Intention to remain
160311 Kirklees Early Adopters	Kirklees	Adopter	2	Detached	>1995	Yes	Solar thermal	Energy conservation	suburban	Post-grad	Retired	3-9 years	Interview transcript	Unassigned	No planning restrictions	For ever
160311 Kirklees Early Adopters Part 2	Kirklees	Adopter	2	Detached	>1995	Yes	Solar thermal	Energy conservation	suburban	Post-grad	Retired	3-9 years	Interview transcript	Unassigned	No planning restrictions	For ever
160611 interseasonal thermal store	Other	Adopter	2	Detached	>1995	Yes	Inter-seasonal thermal store	Energy conservation	suburban	Graduate	Retired	<3yrs	Interview transcript	Unassigned	No planning restrictions	For ever
170211 kriklees hillhouse community meeting	Kirklees	Adopter		Terrace	<1900	Un-assigned	PV	Unassigned	Urban	Unassigned	Unassigned	Unassigned	Field notes	Unassigned	No planning restrictions	Unassigned
260611 fieldnotes from Wormpotts	Other	Adopter	4	Detached	<1900	Yes	GSHP	PV	rural	Graduate	Working - employed	3-9 years	Field notes	Yes	No planning restrictions	For ever
260611 transcript of wormpotts innovators	Other	Adopter	4	Detached	<1900	Yes	GSHP	PV	rural	Graduate	Working - employed	3-9 years	Field notes	Yes	No planning restrictions	For ever
Notes from own installation of PV	Other	Adopter	3	Detached	1901-1945	Yes	PV	Unassigned	suburban	Post-grad	Working - employed	3-9 years	Field notes	No	No planning restrictions	Greater than 5 but time limited
050311 Transcript of interview with ASHP+ thermal adopters	Kirklees	Adopter	3	Detached	1901-1945	Yes	ASHP	Solar thermal	suburban	Graduate	Working - employed	10-20 years	Interview transcript	Unassigned	No planning restrictions	For ever
070909 Huddersfield Examiner PV adopter	Kirklees	Adopter	1	Detached	1946-1995	Yes	Solar thermal	PV	suburban	Post-grad	Retired	>20 years	Interview transcript	Unassigned	No planning restrictions	5 years or less
110516 transcript of pv rural adopter	Kirklees	Adopter	4	Detached	Unassigned	Yes	PV	Unassigned	rural	Post-grad	Working - employed	3-9 years	Interview transcript	Yes	No planning restrictions	Unassigned

110613 recharge biomass	Kirklees	Adopter	2	Semi-detached	<1900	Yes	Biomass	Unassigned	rural	Unassigned	Working - self employed	10-20 years	Interview transcript	Unassigned	Listed	For ever
110630 PV non green RECharge	Kirklees	Adopter	2	Semi-detached	<1900	Yes	PV	Energy conservation	rural	Unassigned	Retired	>20 years	Interview transcript	Unassigned	No planning restrictions	For ever
110706 PV straighforward	Kirklees	Adopter	2	Semi-detached	1901-1945	Yes	PV	Unassigned	rural	Unassigned	Retired	>20 years	Interview transcript	Unassigned	No planning restrictions	For ever
150311 Kirklees Recharge non adopterHD5 0PY	Kirklees	Non-adopter	3	Semi-detached	<1900	Yes	Biomass	Unassigned	rural	Unassigned	Retired	>20 years	Interview transcript	Unassigned	No planning restrictions	For ever
150411 Kirklees RECHARGE Hydro adopter	Kirklees	Adopter	2	Detached	<1900	Yes	Micro-hydro	Solar thermal	rural	Post-grad	Retired	>20 years	Interview transcript	No	No planning restrictions	For ever
180311 Transcript greenish non adopter	Kirklees	Non-adopter	5+	Semi-detached	1901-1945	Yes	Solar thermal	Unassigned	suburban	Post-grad	Working - employed	10-20 years	Interview transcript	Unassigned	No planning restrictions	For ever
200611 transcipt of solar thermal adopter	Kirklees	Adopter	5+	Detached	<1900	Yes	Solar thermal	Unassigned	rural	Graduate	Working - employed	Unassigned	Interview transcript	Unassigned	Unassigned	Unassigned
240311 Transcript of Kirklees ReCharge Non adopter Mark Hudson	Kirklees	Non-adopter	2	Unassigned	Unassigned	Yes	Solar thermal	Unassigned	Unassigned	Unassigned	Working - self employed	10-20 years	Interview transcript	Unassigned	Unassigned	Unassigned
270111 Transcript interview with recharge renewable energy assessor	Kirklees	Surveyor / Installer	N/A	N/A	N/A	N/A	PV	Solar thermal	N/A	N/A	N/A	N/A	Interview transcript	N/A	N/A	N/A
270111Transcript of interview with recharge program manager	Kirklees	Facilitator / manager	N/A	N/A	N/A	N/A	PV	Unassigned	N/A	N/A	N/A	N/A	Interview transcript	N/A	N/A	N/A
281010 field notes from conversation with PV non-adopter	Kirklees	Non-adopter	3	Semi-detached	>1995	Yes	PV	Unassigned	suburban	Unassigned	Working - self employed	<3yrs	Field notes	Unassigned	No planning restrictions	Unassigned

281010 Transcription of interview with PV non-adopter	Kirklees	Non-adopter	3	Semi-detached	>1995	Yes	PV	Unassigned	suburban	Unassigned	Working - self employed	<3yrs	Field notes	Unassigned	No planning restrictions	Unassigned
RECharge ASHP and Solar feedback	Kirklees	Facilitator / manager	3	Detached	1901-1945	Yes	ASHP	Solar thermal	suburban	Graduate	Working - employed	10-20 years	Interview transcript	Unassigned	No planning restrictions	N/A
Transcript 110509 hydro non adopter	Kirklees	Non-adopter	4	Semi-detached	<1900	Yes	Micro-hydro	Unassigned	rural	Post-grad	Not working	3-9 years	Interview transcript	Unassigned	Conservation area	For ever
110411 fieldnotes from London renew cen facilitator	London	Facilitator / manager	N/A	N/A	N/A	N/A	Energy conservation	Water conservation	N/A	N/A	N/A	N/A	Field notes	N/A	N/A	N/A
110519 cen programme manager + GD	London	Surveyor / Installer	N/A	N/A	N/A	N/A	Energy conservation	Water conservation	N/A	N/A	N/A	N/A	Interview transcript	N/A	N/A	N/A
190411 transcript of gwk programme manager	London	Facilitator / manager	N/A	N/A	N/A	N/A	Energy conservation	Water conservation	N/A	N/A	N/A	N/A	Interview transcript	N/A	N/A	N/A
190411 transcript of slough green doctor interview	London	Facilitator / manager	N/A	N/A	N/A	N/A	Energy conservation	Water conservation	N/A	N/A	N/A	N/A	Interview transcript	N/A	N/A	N/A
190511 fieldnotes from low carbon zone Sutton	London	Adopter	1	Terrace	<1900	Yes	Energy conservation	Water conservation	Urban	School	Not working	3-9 years	Field notes	No	No planning restrictions	Unassigned
Field notes from green doctor visit 190411	London	Adopter	5+	Semi-detached	1946-1995	Yes	Energy conservation	Water conservation	Urban	School	Working - employed	3-9 years	Field notes	Unassigned	No planning restrictions	Unassigned
020311 Fieldnotes from RENEW RK+CL	London	Facilitator / manager	N/A	N/A	N/A	N/A	Energy conservation	Water conservation	N/A	N/A	N/A	N/A	Field notes	N/A	N/A	N/A

Appendix 3F
Example Coding Summary

All data coded to "User factors affecting intention to adopt" for the REcharge scheme

<Internals\050311 Transcript of interview with ASHP+ thermal adopters> - § 6 references coded [6.67% Coverage]

Reference 1 - 2.49% Coverage

The beginning of the story, I suppose, was we identified a want to do some home improvements within the house. Sort of like some alterations, quite dramatic alterations with regards to improving usable space in our second story. So we increased the house by an additional bedroom and an additional bathroom, but in doing that, we also like changed the layout to improve the layout of the house so it was more usable. So that was kind of like the initiative that took us forward with it. My parents had moved to Carlisle a number of years ago, and when they first moved to Carlisle, they got solar panels to do hot water because the village they've moved to, it's not got any gas, it's just oil driven. So where they could sort of improve the consumption of oil, that's what they were looking at doing, which they did. And from my mum and dad having solar panels, for thermal hot water, that's kind of what triggered us to look into the possibility of putting some renewable energies on. Because they'd had a good experience with, through the summer in particular, they don't have to use any oil, in effect, because it's all driven by the sun. So that was, so we'd had somebody with a good experience with solar panels which triggered us look at it. There was also the concern that you hear of, you know, the gas and electric continuously going up, so there was also a push from other angles, from probably the media you could say, for us to look at alternatives. Just because, because bills are going to be going up, and income is not going to be going up as much to match your bills.

Reference 2 - 0.45% Coverage

it was an opportunity,.

Interviewer: A particular opportunity to think about what you are locking yourself into in terms of cost?

Yes. And if we were to take a loan out to do the home improvements, it was easier to get the loan to be a little bit more just to cover those technologies.

Reference 3 - 0.91% Coverage

if it wasn't for the RECharge scheme, giving us that £10,000 loan, for want of a better word, I'm not sure we would have taken it full on, in terms of the two technologies that we went for. Because we ended up where I think it was about 3 1/2 thousand pounds or thereabouts solar, and I think it was eight, nearly 9, if not slightly more, for the air source, without getting the figures out. I can confirm if you need to final figures on those schemes. So that was kind of a lot of money, and it was a lot of money for a chance that we didn't know if it was going to work or not.

Reference 4 - 1.24% Coverage

We had a chat with him, we understood a little bit more, and then we kind of decided that because we want to run underfloor heating which was a big want for us with the renovations we were doing, his advice was that the air source would be a good opportunity to run the underfloor because it runs at a lower temperature. Well, this was kind of new information, new knowledge for us, so we did do that. We've got radiators upstairs. We've got radiators in the bathroom, as well as underfloor heating in the bathroom, so if you like dual fuel and then obviously, you need hot water for your showers and baths out of your taps etc. So those are our requirements and he said the air source would be quite a good option if you wanted to go down that route, it would run the underfloor heating.

Reference 5 - 0.79% Coverage

No, our attitude to the council is still the same . They're lazy buggers.

No they're not. They're not lazy buggers. It's the way the council works. It's not, we both work in industry. Normal industry. If you, a council worker, went to work in industry the way you do you wouldn't last. The councils work in a very different way. I do work with councils, with Bradford and with Leeds, and they work a different way. They think a different way. And you've got to get your head round the way they work.

Reference 6 - 0.80% Coverage

I am green. I wouldn't say I was a green freak, definitely not, but I am conscious that, you know, I've got a little one and I want to look after the environment as much as I can. I can do my little bit and you know it all helps. So we have got a recycle bin, stuff goes in there rather than it all going in the grey bin. I don't leave the tap running when brushing my teeth, for example, you know, just little things like that they all help towards... I think, making it a better place for everybody else.

<Internals\070909 Huddersfield Examiner PV adopter> - § 3 references coded [13.39% Coverage]

Reference 1 - 7.65% Coverage

And what's your motivation? What made you go for that? Was it cost or greenness or a mixture of the two or ...

I'm, as you might have seen from the article I'm a planner by trade, that was my profession, still is,and I've always, my husband and I always been into alternative technology. So for example, when we moved into this house, it had oil central heating and we got rid of that straight away and we actually put in an SA, solid fuel for hot water and the heating. And that did all the cooking as well so although I work full-time with two kids, that was, that and the microwave was my only source of cooking.

Interviewer: that's interesting. So it's a real, real conscious decision. In that case it was not to be dependent on oil? How long ago was that you moved in?

22 years since we moved into this house, and the thing is here there is no gas.

Interviewer: so that's not an option.

In our other houses we did have gas but we also had things like Raeburn's, so we'd always use that. And now, with this, I mean, the boiler system that we put in 22 years ago went about five or six years ago, the boiler burst, and by that time I'd decided, because I do quite a bit of travelling, one thing that doesn't lie well with my green credentials, but on the other hand I planted 200 trees when we moved into this house and I use... I've got wood burners so I use all the trees, you know all the products … I've never bought any wood, I've always used what I can collect or...

Interviewer: this is a really conscious set of decisions that you make around how you live your life, isn't it? Where does this ... you said your husband and yourself had always been into alternative technology, clearly decisions around tree planting, awareness of the implications of travelling ... can you trace back to where that comes from?

Well, I did a geography degree, did planning in my final year but I suppose there was….I've always been a gardener, I've always grown things, so there was the … "Small is beautiful", you know, all the early books in the 60s and 70s that I used to read. So it's been the way I've lived my life for as long as I can remember basically.

Reference 2 - 1.53% Coverage

Interviewer: it certainly sounds pretty comprehensive! Are there … you've been driven by, these are my words not yours, but 'doing the right thing' and 'oing the greenest, the most sensible set of things', is that about costs or is it about energy being a precious resource or…

It's ... I grow my own food as much as I can, ... I've always been ...

Interviewer: it's the way you want to live?

Yeah., Good Life, 1970s, that's me.

Reference 3 - 4.21% Coverage

Well, I suppose, one of the driving forces round where we are, as I say, is that a lot of the properties don't have gas. You know in the main settlements you got gas. You're a bit isolated, which is what I am up on my hillside, then you don't have gas. So that's always been cheap hasn't it, whereas the majority of houses round here had to use oil or solid fuel, as I did. I think that is quite a strong driving force. I mean where I am, the house is very visible, it is on the front both the solar and the photovoltaics, so anybody coming up the hill, and it's on, it's not a main route but goes past the school up onto the top, so it is actually quite visible, so a few people have stopped me and said. "oh, how did it go, what's it all about?" And I think people round here are very careful with their money! So, you know, wind turbines, initially they're very costly but like, I mean, Moorside Edge which isn't far from me, I gather that they repay 3000 in a year, it's suitable in a number of ways. In terms of ideology, I'm not so sure. I mean, people think I'm quirky round here. You know, I've lived this life style for 22 years. I'm an odd woman. That's the general impression.

<Internals\110516 transcript of pv rural adopter> - § 4 references coded [13.77% Coverage]

Reference 1 - 2.20% Coverage

My wife was at the swimming baths with the kids. Next to her was sat a lady and they started to chat. And, I don't know what exactly she did, but she was somehow.. knew about the REcharge scheme she worked for the council. And she said, 'oh well if you're interested in that kind of stuff, 'because we already got solar water heating, 'if you're interested, go to the REcharge scheme' because the first hundred or whatever it was,

Reference 2 - 6.37% Coverage

Well we put the application forms in and it then took several weeks for anybody to come round to assess, because it seemed that locally they chose one supplier. He comes round and it's one man basically, with a team of guys and he's going around these different places doing the evaluations. When he came round to do the evaluation after several weeks. After he found out, you know ... well let me drop back, the first guy came round, assessed your house everything else, yes that's fine. After that when it came down to getting the survey done, that took several weeks. It took several weeks after that to get the offer through. And I'm ringing up. Now the girl you ring, is in the council. Yorkshire energy office or whatever it's called. Who then contacts the supplier guy. And it's this triangle of conversations, you eventually get a quotation through, a lot more than the amount. I don't want that. ....so he says he'll come out again, comes out, another chat through. So this whole process, took, I don't know, month after month after month, and it was ...er.... It got to the point where actually my father and mother in law got through to this process as well because we told her about it, and they said "oh, pack it in", they'd had enough.

Reference 3 - 0.97% Coverage

what's my real motivation here, yeah, I want to save the world and everything else, but I've got 2 kids and a wife and 2 dogs and 2 cats and horses and stuff, so it's got to pay for itself.

Reference 4 - 4.23% Coverage

would you say that there is any interest in what you called saving the planet and that kind of thing or is it as far as you're concerned just straight, a financial interest and anything you might do in terms of home improvement are assessed on their financial interest rather than whether or not they're good for your soul?

Yes. Well, things are prioritised. So the top of my agenda is can I afford to do it? And sustain it? And if the answer is no, it doesn't matter what it is, I ain't going to do it. So the first one has got to be the household finances. And if in doing so that makes things better, great! And everybody is the same. I mean if I had £1 million to throw away, course I would love to do all these different things. Even if it didn't make any financial sense. It would be great. But who's got money to burn?

<Internals\110613 recharge biomass> - § 4 references coded [8.48% Coverage]

Reference 1 - 1.30% Coverage

We were on LPG because we don't have mains gas and the boiler broke down. We'd only had it eight years, I thought that was, you know, not very good. And our daughter works for what was Kirklees Energy Services, you know, so she gave us the information plus I lean to the.. towards the environmental side in interest, I mean.

Reference 2 - 0.72% Coverage

It just seemed nice to be able to go green and I hoped it was going to be also more cost efficient, more efficient, what have you, than LPG might be in the future so ... that's ...

Reference 3 - 1.53% Coverage

Right. Well, we did have cavity wall insulation in our first house. Back in the 1970s. Let's see, just guess and say 1980s something like that. Which we didn't have anybody else had had before. And I just thought, nothing special, just ordinary recycling and, you know, we run one car instead of two, a small car rather than a big car, you know, just things are easy to do really.

Reference 4 - 4.93% Coverage

Well, what I would like, if I could afford it, I would like PV. We did look at it because we were offered like a family discount sort of thing. And, to cut a very long story short, they cocked up the survey. We couldn't have it on the roof because of the listing but we got planning permission to put it on the garage roof which is flat. And when they turned up to install it in January, the survey was totally wrong. They couldn't, we were down to have 12 panels and they could only, there was only space to properly put six on. So then, what they did say was, basically they took everything back, but they did say was they could put it on a frame in the back garden, then the issue with that is, the area of the back garden where they would install it, plus sorry, it's not only the size of the roof, it was also partially shadowed in winter, not at this time of year, so to set this... to set them up on a frame in the back garden, well, two thirds of our back garden is rented from Lord Dartmouth. So I thought that might cause problems so I sort of put it on a backburner and did think let's get the boiler sorted first. To be honest my wife's a bit, it's affected her more than me and she's not keen on looking at something else.

<Internals\110630 PV non green RECharge> - § 2 references coded [7.93% Coverage]

Reference 1 - 3.56% Coverage

Perhaps you could begin at the beginning for me about how and why you first started looking into it. Were you looking into the scheme or were you looking into photovoltaics takes any way or ...?

No, it's just that I heard that somebody down the road, they had this system and more to the point that it had cost them nothing. So I went on the Internet and the....they call it the something Trust.

The Carbon trust would that be?

The Carbon trust. And also the Kirklees website. I applied online £2500 from the Low Carbon Trust and was amazed to find a minute later I had an e-mail saying, 'yes, here's the money. Where do you want to paying to'?

Interviewer: so that exceeded your expectations a bit!

Well, yeah. It's the easiest 2 ½ grand I've ever made.

Reference 2 - 4.37% Coverage

was it a financial motivation that made you look at it? Was that the main reason looking at it?

As far as I could see I was getting something, the panels, for nothing.

Interviewer: but it was that the income stream rather than ...

I don't give a monkey's chuff about greeness. I think a lot of this green stuff is a government deployed to impose taxation on people, to be honest.

Interviewer: Right. And I don't know what kind of energy setup you've got, whether you've got dual fuel or not but are rising energy prices one of the things that, you know, was it a consideration that photovoltaics might reduce your….

I'm the sort of guy who runs his car on LPG because he doesn't have to pay the tax on it that he has to pay on petrol.

Interviewer: Right. So you're very informed about the relative costs and benefits of, financial costs and benefits….

As far as I was concerned, if it made me, £900 a year is what was quoted.

<Internals\110706 PV straighforward> - § 4 references coded [14.58% Coverage]

Reference 1 - 4.54% Coverage

Was photovoltaics something that you were considering or ...? How did that actually start.

Well, we ... I mean, hovering in the background is lowering our carbon footprints, but that's only hazily in the background.

Interviewer: is that something that you were aware of, anyway.

Yes. Also, we are on oil. We aren't on gas. So therefore our house is heated by oil and the price of oil over the past four or five years has shot up. And it's subject to the government, what do they call it, the government ... organisations which keep an eye on energy and the cost of electricity and so on. We were a bit aware of that. And Kirklees, amongst other councils, what had happened was that they said 'oh, basically we'll give you some help towards having cavity insulation.'

Reference 2 - 3.16% Coverage

there was a bit of a coincidence there, that that we were feeling a bit peeved about not being able to get cavity wall insulation and having paid for our own loft insulation, and then he said, 'well actually there is this other stuff'. So that really got us going. And yeah, it was the fact that you got the loan, interest free, 10,000 quid only repayable when the property was sold, I mean we are in a mid 60s so we might die in the house, so the loan really is insignificant, really. It is not insignificant but it's not a major thing.

Reference 3 - 0.59% Coverage

they were offering other stuff like ground source heat and air, but that seems a bit more complicated

Reference 4 - 6.28% Coverage

I wondered if there were other activities or other home improvements and the like that you had in mind where this hovering carbon footprint was something that you are aware of? I'm thinking about food or transport or other elements there?

Not significantly, I don't think

Interviewer: okay. And do you belong to any, organisations or groups that you might consider green? Are you members ...

Well, we ... in Slaithwaite, in the Colne Valley, there really is a green grocer that shut down, closed, and it was taken over by a cooperative. And the local people were invited to buy shares in it.

Interviewer: the Green Valley grocer, yeah?

That's right. You've heard of it.

Interviewer: indeed yes. I've been talking to a number of people around the area and it's an interesting, it's a really interesting project that comes up, yes. So you're shareholders are you?

Yes. Which sort of entertains a green agenda, you know, sourcing food locally is perhaps the main one. So that is an organisation that we belong to which is has a sort of, certain green credentials.

<Internals\150311 Kirklees Recharge non adopterHD5 0PY> - § 5 references coded [8.85% Coverage]

Reference 1 - 1.05% Coverage

can you tell me about what prompted you to think about a biomass boiler for your property?

No idea. You'll have to leave that one for my husband to come in. I don't know why we did that. I've no idea. I don't know the answer to that at all.

Reference 2 - 3.71% Coverage

I wanted, I personally wanted to be warm before we had this boiler in we just had an open fire, well I mean obviously, my husband wasn't coming home from work until about 5:30, lighting the fire, it takes a good hour or so to get the house reasonable before we put the pump on to warm upstairs. I mean it was, it was all right, we couldn't afford to run it all day. Oh it would be tremendous the bills. Probably it is a bit cheaper because during the very cold weather we did have it alight all day. We haven't been doing lately because it's been nowhere near as cold, is it?

Interviewer: no. No.

But during that very cold weather it was alight all day.

Interviewer : Right. Okay. So you've definitely got some benefits in terms of the comfort, which is good. Okay. So it wasn't, it wasn't the energy bills that would driving you per se or particularly?

No.

Reference 3 - 0.61% Coverage

We had a high output back boiler, but it wasn't quite adequate because we've extended the house a few years ago, added a long extension and ..

Reference 4 - 2.02% Coverage

what's green technology?"

Well, it's obviously something that doesn't put any sort of harmful emissions out. And that's what, these pellet boilers aren't supposed to do, are they? Well this thing we've got now, it doesn't... well it does a bit, I suppose, it burns smokeless fuel which I suppose is reasonably... and the logs are mostly logs which we've felled ourselves from the garden. Ash and stuff. So it's not really ... I don't know whether you class that as green.

Reference 5 - 1.46% Coverage [1]

Do you do anything that you consider to be green or environmental ? Or is that not just something that you interested in?

Well, I don't suppose we do really.

Interviewer : That's absolutely fine... I'm curious, don't worry , it's not a test.

I drive a car. That's not green, is it? You know things like that. We're just normal people. No.

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[1] Ref5 above cross-references with Appendix G, the coding log

<Internals\150411 Kirklees RECHARGE Hydro adopter> - § 4 references coded [5.87% Coverage]

Reference 1 - 0.34% Coverage

you said you're very informed about green issues. Has that been over a long period of time?

oh yes. Being South African, when I was a child the water came from underground with an old windmill. In the middle of nowhere.

Reference 2 - 0.46% Coverage

perhaps the beginning of the story is when you thought there is a practical chance here to put another bit of a dream into action, put a hydro scheme in place....

Sorry to disappoint you. It's not practical. What I've done will never make money. It will never pay for itself. It's my train set.

Reference 3 - 3.63% Coverage

Are these opportunistic things, or...?

No. They're born of necessity and again enthusiasm. We came to live here. We were very poor and we were building a building, we had two children, just my single salary, my wife's not working, looking after the children, the usual story and it's an old, cold house. It leaks. Solid walls. I did my best to insulate them, these solid walls insulated with bacofoil. Back in the 1970s, there was not too much known about insulation and building, and the floor has ....mixed into the floor screed is mica-schist which was used in blast furnaces to insulate blast furnaces and I mixed that with ..... I did my best to insulate back in the 70s but in modern terms it's absolutely horrible, useless. It needs gutting and dry lining. It needs insulating inside. You can't insulate the outside because of the nature of construction. So I need to gut it, and reinsulate which I will get round to one day, I think. Fortunately we have the other house we can move into while we're doing it. But heating the house in the early days, even when coal was £50 a tonne, that was a hell of a lot of money in those days so I started at tree surgery business. I was the first one in Huddersfield actually there were no tree surgeons as such in those days. And being an educated person I got hold of the relative British standard. British standard 3118, I remember it to this day and I started selling trees for people who knew me in return for the wood. So I had free fuel. And then one day I was driving home in my battered old Land Rover with chainsaws and logs and a tree in the back of my truck, in the back of my Land Rover in the trailer and I stopped at a pedestrian crossing in Huddersfield next big park, green acre park, and an elderly woman started waving at me. I thought 'Oh hell, something's dropped off the truck, I better stop and see what it is'. I pulled over and got out and she then asked me did I cut down trees? She said 'would you come and look at my tree?' and she lived just round the corner, in central Huddersfield, it was a large old cherry tree, which was pulling, like a lot of cherry trees was pulling up her garden paving and she wanted rid of it. And I said 'yes I'll do that for you'. Then she said "how much?" And I thought hellfire, I get paid for my own fuel. So I then put the thing on a proper footing and I was

Reference 4 - 1.44% Coverage

But there was huge resistance from people. They couldn't see the benefit of it. Irrespective of me saying to them "how much did that car on the drive cost?" £25,000. Audi in this case. And what will it be worth in 10 years time? £1000 if you're lucky. I said "okay, wind turbine £20,000. What will it be worth in 20 years time?" Okay, so it's only got two moving parts and the money you put into it like the concrete base, the cabling, the inverter and so forth are virtually going to go on forever. After 20 years the only thing you have to replace is the foil, the wing, and possibly the bearing on the thing that turns it round to face the wind, so very little to do to maintain them. The maintenance isn't ... why don't you put one up? Oh no. I've published pamphlets exploring the virtues of these things. The uptake until recently has been very, very poor. The feed in tariff has made a huge difference and now everybody is at it now.

<Internals\171111 notes from hydropower installer presentation> - § 1 reference coded [28.70% Coverage]

Reference 1 - 28.70% Coverage

I asked PH what made a difference to propensity to go for micro-hydro, other than the technical feasibility factors, he thought that the history of mills in the landscape might make a different (powerinthelandscape.co.uk) but his first response was "cash". You have to have, or have access to £100k for a scheme, even if it will payback, with FiT in 10 years, and Fit payment are guaranteed index linked for 20 years. Look at the South Somerset hydro group, a group of mill owners who have got together to develop hydro projects, they have 5 or 6 big projects up and running already, in places like Bath and the edge of the Cotswolds, compare that with the West Yorkshire mills that were bought for peanuts in the 1970s by people who wanted to scratch away at self sufficiency. Those people have done ok and their properties are now worth a lot more, but rarely to they have capital reserves in the way the south Somerset group do

<Internals\180311 Transcript greenish non adopter> - § 2 references coded [2.00% Coverage]

Reference 1 - 0.87% Coverage

My husband and I are fairly green people and we really wanted to do something that was good for the environment. So we came at it philosophically, thinking what can we do to improve our energy use and be greener. And there weren't many things we could do at the moment with our house and our finances as they are

Reference 2 - 1.13% Coverage

But we thought this RECharge scheme sounds good because, in fact, I know the local Green politicians who, sort of, put it forward, on the council and we'd met Andrew Cooper in the past, who was one of the local Green councillors who, I think, sort of pushed for this RECharge scheme to go ahead. And I heard about it in the local newspaper and saw leaflets and then thought, "Brilliant! We'll Sign up."

<Internals\200611 transcipt of solar thermal adopter> - § 1 reference coded [2.40% Coverage]

Reference 1 - 2.40% Coverage

Well basically, my parents' main aim was to save money. Up here we're on oil and it, the price of oil has just soarn recently over the past few years. And, you know, it's getting very expensive to run our boiler. I mean, you know, it's fine, we can still run it and things but what we wanted to do was to have something that could contribute to that.

<Internals\240311 Transcript of Kirklees ReCharge Non adopter Mark Hudson> - § 2 references coded [11.98% Coverage]

Reference 1 - 10.28% Coverage

why you were looking at solar thermal and how you came across the RECharge scheme if you can, if you can remember.

I think it was just word-of-mouth.

Interviewer: Right. Okay. Was it a while ago now ?

Yes. Last year.

Interviewer: okay. So word-of-mouth, you knew somebody in the council or you knew somebody nearby?

Neighbour. Neighbour.

Interviewer: Right okay. Have neighbours actually got ...

They've had solar thermal. But not too happy with it.

Interviewer: Right. But even though they weren't too happy, you still felt it was worth looking into?

No, that wasn't until afterwards. They were having it done at the same time as my enquiry.

Interviewer: Oh, I see. Okay. So ... and, what was it that they said or what was it that was made you think, "hmm, this is worth looking into for us?"

It was just general. It was just a general acceptance that the sun is better to heat water and electricity and you know, electricity, rather than paying for it from the grid and release the burden from the grid, I think it's going to become inevitable.

Reference 2 - 1.71% Coverage

... I think everybody's attitudes are selfish, aren't they, really? So I think it's just general cost and then, overwhelming to do with the current state of affairs, newscasts...

<Internals\270111 Transcript interview with recharge renewable energy assessor> - § 3 references coded [7.02% Coverage]

Reference 1 - 1.32% Coverage

They don't want too much detail, some people want a lot of technical staff, they've obviously done their research and as soon as I was through the door, "How many volts will this do? And how many Btu's will that do?" And I have to say, "Whoa, whoa, whoa. Slow down."

Interviewer: And presumably in the RECharge scheme you get more of those kind of people?

At the beginning we did. Because there were quite a few council staff and quite a few, a good old technical term, Guardian readers, so you've got quite a bit of that at the beginning and then once that sort of tailed off and it was the general public coming in, who'd seen adverts in the local press, flyers and one thing or another that Kirklees did.

Reference 2 - 4.73% Coverage

The new development up at a big complex of houses, I think they've been up about 18 months, two years now, and I went up there probably four, five months ago to do one of the last REcharge surveys and when I got there the roof was covered in PV. And they'd had one of the 'A shade greener' kits put on, 3 kW, so I'm thinking right, they can't be talking thermal because there's no roof left. So I went in and I said, "I see you've already got PV. You've got the thermal. I'm hazarding a guess here that you're thinking air source." "That's it. How did you guess?" Well I'm thinking, you're thinking it'll run the heat pump during the day and then when the RHI comes in you get paid for that as well. So then it's a definite contender because the heat pump is run by the PV, RHI then pays any extra, they will be doing quite nicely come June so....

Interviewer: That's interesting. Now with that particular case, so those people have been doing their research, were they in the trade themselves?

They had been doing their research. No, an Indian family. The mother lived with them like a lot of Indian families I've come across do. And she'd got like bit on the ground floor. It was one of these modern houses with three storeys, you know. So they'd worked out, they know they don't get anything out of "a shade greener" apart from its on their roof, but they get the use during the day, so they'd worked out all the appliances were on plug-in timers or they bought stuff with delay timers so they could switch everything on during the day and they started looking at it and they got permission to put in an air source round the back and of course you had to have planning permission for it, apparently it's changing shortly, it will be permitted development, and they thought, so apparently they put in some spreadsheet or something or other and it came out, "hmm, this is not a bad idea!" So, because the heat load of the building, even though we complain about British building, the heat load of this three-storey thing, with four bedrooms, three living rooms, was only 12 kW. So it was very well insulated for a modern built house so...

Interviewer: Is that an unusual kind of ... having the level of planning and thought ... it strikes me as unusual...

It is. I just thought I'd take a punt here and say I bet you're thinking about ... and yep, that's it and they were straight into all the stuff. Right, fine, okay. You know what you want, so that's great. I thought, no, I wish more people were like this. But you couldn't do it in an old house.

Reference 3 - 0.97% Coverage

Interviewer: Does it matter what the neighbours are doing? Do you find that people are influenced by what other people in the street or that they know somewhere else might be doing?

Not at first because there most of the time there was nobody in immediate sort of visual area with anything. So it was a case of these were going to be like leaders in their little community so.... And then a bit later on, we ended up with a few which were nearer, and it was word-of-mouth. "I heard about this from so-and-so and whatever..".

<Internals\270111Transcript of interview with recharge program manager> - § 2 references coded [5.57% Coverage]

Reference 1 - 5.18% Coverage

Yes, well I think at the end of the first year of the scheme we looked at the take-up, the figures were skewed by the fact that there were early adopters, I guess, there were people who had been really keen, just been waiting for the moment when the council would launch this scheme, they were the early adopters of the scheme, but then as we went on we did find that the appeal had broadened. We did some more, kind of, direct marketing to address increasing the number of households in fuel poverty. We talked, we did things like talking to the affordable warmth strategy group members, informing the front line workers that were going into properties about the scheme, so spreading the message out across the council, so things like Gateway to Care and looking at, sort of, sending out the message through already established networks to reach those householders. And then we also wanted to address the ethnic, the ethnicity of the take-up of the scheme as well, because, again in the early days, we'd found that it tended to be the white British take-up so we just wanted to do something to address that as well. So we set ourselves our own target to reach, so 10% of the funds to go to BME households and again we targeted the marketing through that. So over the summer we used the local radio station that runs over the summer and other publications going out to that target audience, and to, we did find at the end of the second year that we've surpassed the fuel poverty target, I think we're running at about

24% now, the target was 10%, and on the BME take up, I think we're about 7 to 10%, so I think that, for us that strategy worked, and also I think it was, it is a reflection of those early adopters being of a particular make up.

Reference 2 - 0.38% Coverage

VD commented that anecdotally they've heard that near neighbours have an effect, "particularly on the PV, because it's so visible"

<Internals\281010 Transcription of interview with PV non-adopter> - § 3 references coded [3.92% Coverage]

Reference 1 - 1.91% Coverage

Yes. I'm very interested in green technology. I've researched it. Obviously, I owned a building, plumbing company. Obviously we fit lots of green boilers, you know, different sorts of systems, so yes, that was one of the reasons why I got involved in it, the RECharge scheme because I searched for it.

Reference 2 - 1.12% Coverage

Obviously, I mean, I'd be a liar to say it weren't to do with money because, obviously in this day and age I were cutting my bills down but obviously I was benefiting the world.

Reference 3 - 0.90% Coverage

I don't ever think that solar were very good, solar hot water. I think that were a mistake. But everyone will have their own opinion on that.

<Internals\Transcript 110509 hydro non adopter> - § 1 reference coded [1.66% Coverage]

Reference 1 - 1.66% Coverage

Interviewer: so you're a very informed, in my jargon, you're a very informed decision maker or consumer, you know, and your interest was in reducing your impact not necessarily only in reducing bills. Or am I making the wrong assumptions?

No, in the first instance it was, you're absolutely right. But as our circumstances changed and, again, with my health and not being able to work full time, we then had to start thinking about reducing bills and also thinking about what would happen in the future in terms of oil prices and fuel prices.

Appendix 3G
Excerpt from Coding Log

Thoughts and observations during coding

From 110725 PV installer and adopter

User attributes ... the arts/science divide, typified by "I don't do technical" is a bit different to the perceived behavioural control or social norms – isn't it? Something more about self-perception and competence / interest? Validity of the science world view?

There's an interaction between user attributes and technology attributes, particularly around PV, and maybe the sociodemographic attributes of place as well. E.g. a comment about not being able to afford PV without grant help involves user attributes (wtp), technology attributes (cost) and sociodemographic attributes (affluence). [also from Kirklees early adopters part 2] the desire to select materials based on local sourcing and sustainability criteria links (in adoption), user attributes(subjective norms, attitude towards action, knowledge, research capability) and technology attributes (materials selection, manufacturing location).

From 110727 PV non-adopter No 8 garden

Will need to check through about consistency with which I've coded an individual's perceptions of the place where they live – before I started using the "area selection" codes.

I haven't coded the user's commitment to a place – although it could become and extra attribute in the case file? Values would be – long term / indefinite commitment, expects to move in the next 10 years, expects to move very soon, unassigned and not applicable.

From 121011 Ulrome hiller

I suspect I've been a bit inconsistent in where I've coded things about 'practices' e.g. the need for an airing cupboard. Factors-affecting-use is what I've chosen today!

From 150311 Kirklees Recharge non adopter

Struggled with how to code "Do you do anything that you consider to be green or environmental? Or is that not just something that you interested in?/ Well, I don't suppose we do really. / Interviewer : That's absolutely fine... I'm curious, don't worry, it's not a test./ I drive a car. That's not green, is it? You know things like that. We're just normal people. No."... but eventually realised that this is an example of user subjective norms/self-perception and coded it under factors affecting intention to adopt.

From 150411 Kirklees RECHARGE hydro adopter

Story of Environment Agency has been coded as a location factor in the intention to adopt – but it's really an institutional factor (a bit like planning?) so I'm not sure if it needs its own....

Also aware that the 'user attribute – knowledge' as in technical knowledge doesn't fit neatly in with the three sub categories from TPB. So have coded them at the top level of user attributes....

Notable that this interview, which felt very rich at the time, actually provides little codable material. However, it was a critical conversation in shaping how I probed and asked in later conversations...

From 160311 Kirklees early adopters

How to use the information about NGO membership etc.? I asked people about it as a way of getting at user attributes – spillover actions what information shapes their views etc.... but it's rarely linked to a specific issue of intention or adoption.

From East Riding and case data on use of IT

For the older adopters, IT is a divisive issue. Where they have adopted it, it is used for service provision (on-line banking and shopping) and research (Totnes, Kirklees) but where they don't have IT then there is frequently expressed anger and frustration at the fact that the assumption, particularly on TV, that everyone has internet access.

From 160311 kirklees early adopters part 2

Joiner provided info that led them to identify sustainable roofing materials... links to Rogers' channels of communication and info flow. Not sure I have a need category for this in the coding so have just put it at 'factors affecting intention' level. Need to see if any other Rogers' categories come up.

User attributes needs to include 'user lifestage' i.e. the design for accessibility should one occupant need a wheelchair, plus design for low maintenance as both occupants are retirement age...

Modified the node of “installation process” at use to “installation and maintenance” ... prompted by comments about making the house wheelchair accessible and placing PV panels where they could be cleaned by occupants without ladders.

Interesting to note that the interviews that felt very rich (this one, the Kirklees hydro one) actually yield relatively sparse amounts directly related to the research questions. But they did inform how I thought about research questions and framed further interviews!

From interseasonal thermal store

Coding attitudes / motivation at “user attributes” in intention to adopt .... and may need to divide these further to separate out those with green and financial orientation/motivation, also differentiate between climate motivations in green (No 16 Brooklands) and motivated by avoiding waste (Tony’s house).

Modified the node of “installation process” at intention to adopt to “installation and design” ... prompted by comments about development architect.

On PV, when I look at all the technology attributes, will need to be able to sift out the ones that are linked to policy i.e. the cost-attractiveness of PV is linked to a temporary or policy-designed set of technology attributes, not intrinsic designed attributes.

Appendix 4.1A
Data Summary for RE:NEW Case Study

	Intention	**Adoption / non-adoption**	**Use**
1 Adopter N=2	Place? (1) (existing networks provide prompt: carers' network – acquired place attribute) Technology? (1) (cost - last quarter's energy bills the highest yet) User? (0) Installer? (4) (existing boiler maintenance always reminds householder of age of boiler) (installer uses council brand as this shapes favourable response) (branded van can elicit enquiries) (installer is empathetic and trying to help, not sell a product) Other: Trigger for a need to redecorate/refloor (tomcat!)	Place? (3) (very hard water restricts showerhead flows) (householder willing to provide referral to neighbours) (garden small and not used a great deal so composting not seen as relevant) Technology? (7) (cost and guarantee for boiler) (cost of double glazing) (cost of energy) (performance of CFLs) (existing fittings non-standard design so flow-restrictor couldn't fit) (existing chandelier fittings wouldn't take CFLS) (new showerhead improves flow) User? (2) (felt unable to make things happen on her own) (didn't know how to fit free flow-restrictor that had arrived in mail) Installer? (2) (able to make appointment for loft	Place? (0) Technology? (0) User? (6) (householder prefers drying clothes outside to tumble drying) (tea is made by boiling water in pan not kettle, for taste preferences) (user believes that having heating on when she gets up induces migraines) (teenage daughter's shower usage) (wants instructions for husband and son to review) (energy intensive uplighter important for religious study in that space) Installer? (4) (left mobile number) (plumbers often uninstall eco-beta) (visual display set up and installed – but leave instructions as well)

	Intention	Adoption / non-adoption	Use
		insulation seamlessly) (council contact essential to overcome scepticism of something that's free) (installer is empathetic and trying to help, not sell a product) (provided warning that it's normal for showerhead to dribble a little)	(packaging removed to avoid resale)
2 Non-adopter	No data	No data	No data
3 Facilitator / Manager N=4	Place? (6) (neighbourhood is what can be accessed on foot, not local authority area, neighbour recommendations vital – 16% of visits booked through neighbours) (accessing HMOs and private rented still difficult) (warm up through council branded letter-drop) (tenure and density) (use of existing community groups e.g. WI, Sure Start) (visiting age-related community groups) Technology? (5) (visual display monitor as a freebie was the best way in) (visual display	Place? (5) (scheme needed to be relevant to mix of housing stock) (high proportion of private rented and landlord-tenant comms) (parking hassles for installers) (HMOs) (housing types, dormers in flats...) Technology? (6) (quick to install? E.g. radiator panels probably slowest items) (finding the lofts and cavities that need insulating) (cost-effectiveness not enough) (wireless energy monitors look cool) (wireless energy monitor highlights different user behaviours in the	Place? (0) Technology? (1) (operating heating controls is not easy for most users) User? (1) (difficult to promote preventative measures – benefits are remote from action) Installer? (4) (remove packaging to avoid resale) (return visits a month or so after installation, when things are less stressful, would be more effective

	Intention	Adoption / non-adoption	Use
	unit looks cool) (time taken to install may stop it being offered) (understanding of the cost of water heating) (showerheads look nice) User? (6) (too busy) (not in) (renting – so it's the landlord's problem) (seems like hassle) (private renting – it's not my responsibility) (hassle of clearing loft) Installer? (5) (branded vans help people approach installers) (interpersonal skills on the doorstep) (being seen as real genuine people at community meetings – not faceless) (start with enthusiasm and add technical skills later – CEN) (willing to engage with whole household inc. children) Other: estate agents unwilling to get involved in case it makes rental more difficult	household) (costs of wireless monitors) User? (3) (hassle of clearing loft) (lofts are used for storage) (like comparing the impact of behaviours e.g. showering ' get out the shower!') Installer? (2) (interpersonal skills in combination : offers tailored advice and "handy enough" to install easy measures) (avoid detailed technical reports and SAP rating)	with heating system installation) (heating engineers aren't natural advisers) (give people the info they need, not huge technical reports)

	Intention	**Adoption / non-adoption**	**Use**
4 Installer / surveyor N=2	Place? (4) (snowballing overcomes initial scepticism – CEN) (council brand helps 9 times out of 10) (lack of water meters due to high numbers of flats) (local volunteer groups can be good doorknockers Haringey) Technology? (2) (can I help you save money) (draught proofing cheaper than a new front door) User? (4) (don't want nanny state) (willing to take a punt on something interesting) (recognising what's negotiable - koi carp!) (tiered levels of difficulty) Installer? (5) (keep it short and sweet – can I help you save money) (quick response to referrals – quicker than housing service) (personal satisfaction in avoiding waste) (sensitivity to what	Place? (4) (momentum builds towards a deadline) (local contractor who knows street configurations, parking etc.) (parking) (degree of community identity – more commuters, harder going on recruitment) Technology? (11) (likes the modular design of reflective radiator panels) (loft insulation can incorporate a 5m2 storage platform) (radiator panels are comprehensible) (quick to install and immediate demonstrable benefit – showerheads) (if free, people will trial and not feel too bad about discontinuing) (people like shiny things) (free equipment helps) (wireless monitor displays cost not consumption) (simplicity is helpful) (does the easy measure fit with house aesthetic?) (ease of installation) User? (5) (elderly less keen on gadgets) (difficult	Place? (0) Technology? (5) (thermostats can easily be changed after visit i.e. highly reversible) (LCD screens not comprehensible for a lot of people) (wireless monitors often not used on return visit – job has been done) (visibility of shower timer may matter more than information/timing) (easy measures rejected if they don't look good or don't provide functionality – shower heads and CFLs) User? (3) (I don't do jumpers inside the house) (powerdown plugs change TV standby routines) (baffled by LCD screens on heating controls) Installer? (0)

	Intention	Adoption / non-adoption	Use
	else is happening in household e.g. bereavement, hoarding) (not combative – choosing points of intervention)	to make the connection between hot water usage and energy) (powerdown plugs appear to complicate a routine re standby) (will not call or cancel appointment for insulation if follow through isn't immediate) (environment can = waste / environmental health) Installer? (10) (can make appointment for loft insulation seamlessly) (need to be able to make insulation appointment straight away to ensure follow through) (immediate action on heating controls and trying to empower users by showing them what to do) (latitude to offer tailored advice) (identifying opportunities from multiple signals) (need to demonstrate to overcome myths of poor performance e.g. CFLs) (repair and rectify errors immediately) (might be biased against difficult to install items) (minimise number of visits to minimise dropout) (caution in not increasing vulnerability of some users e.g. temperature settings)	

Appendix 4.1B
Data Summary for WarmZone Kirklees

	Intention	**Adoption / non-adoption**	**Use**
Adopter	none	none	none
Non-adopter	none	none	none
Facilitator / Manager N=2	Place? (2) (integrated ways of delivering stat duties) (universal benefit so increases social cohesion 'binds communities together') (local political leadership and x-party working) Technology? (1) (PV is fit and forget) User? (2) (social norms – public health analogy) (attitude: uninterested or attitude : other factors more important) Installer? (0)	Place? (5) (area interest in fuel poverty and housing) (area interest in economic development in GT) (site availability) (local public perceptions – residual memory) (planning ok but 'tightly managed') Technology?(4) (fit and forget) (visual impact) (noise impact) (physical tangibility – CO monitors) User? (0) Installer? (2) (time lag leads to non-adoption) (separate recruitment from installation)	Place? (0) Technology? (1) (fit and forget – requires nothing from user) User? (1) (social norms change over time) Installer? (0)
Installer / Surveyor	Place? (1)	Place? (2)	Place? (0)

	Intention	**Adoption / non-adoption**	**Use**
N=1	(reputation of installer in area) Technology? (1) (perceptions from 'old builder', new tech is different) User? (2) (personal recommendation) (beliefs and experience – old time builder) Installer? (1) (salaried therefore no pressure sales)	(Building type – stone facing) (need to work with neighbours on access) Technology? (4) (cost – free and therefore perceived low value) (whole package including scaffolding offered seamlessly) (other skills e.g. dealing with gas fires / ventilation) (manufacturer's standards and industry guarantees) User? (1) (didn't value free service) Installer? (9) (combination of technical knowledge and flexibility to respond to customer concerns) (salaried therefore no pressure sales) (technical skills across multiple systems e.g. gas fires) (uniform and identity – visible van with logo) (provide all relevant information) (contact neighbours if relevant) (exact and rigorous health and safety standards) (take care of other fabric	 Technology? (0) User? (1) (limited technical knowledge – damp visible) Installer? (1) (need to respond rapidly to rectify issues)

	Intention	Adoption / non-adoption	Use
		e.g. chipped laminate floors) (respect - overshoes etc.)	

Appendix 4.1C
Data Summary for Transition Streets Totnes

	Intention	**Adoption**	**Use**
Adopter N=6	Place? (1) (grant availability) Technology? (6) (cost – capex) (cost – opex) (FiT income) (capex cost and effectiveness) (eco-aware brand is used rather than research) (high capex) User? (10) (interested in environmental issues and reducing impact) (longstanding environmental interest) (just moved in – wanted to meet neighbours) (knowledge of resource	Place? (6) (grant availability) (grant availability made participation worthwhile) (older property and roof influenced siting) (scheme bulk purchase reduced cost) (followed neighbour's siting solution on garage after initial 'no') (word of mouth information) Technology? (8) (capex) (cost – high compared to fixed income) (disruption of installation[1]) (FiT income changed affordability) (PV much simpler – less complex- than ST) (needed fast response to replace boiler and ST complexity mitigated this)	Place? (0) Technology? (5) (needed to explicitly request wireless monitor) (inverter information shut away in a cupboard) (inverter information in attic and monitor extra cost) (electric tripped once – reason unclear) (no action required from user other than taking meter readings!) User? (9) (understanding of how technology and use worked) (plus resources to resolve confusion) (understanding of how technology worked – incorrect)

[1] This doesn't refer to PV, but to a backboiler on woodburning stoves, but is in this analysis because it indicates the attitudes held by someone – an adopter- who is in the PV scheme.

	Intention	Adoption	Use
	use from wireless meter) (dislike of waste) (pro-environmental attitude) (desire to be frugal) (desire to reduce env. impact) ('just getting round to it' – i.e. prioritising) (broad environmental interest – appreciation of nature, species loss) Installer? (1) (provided practical knowledge e.g. inverter would hum)	(draftbusting fan made energy losses visible) (reversibility – having taken out hot water tank makes micro-heat options limited) User? (5) (understanding of how technology and use worked) (busy-ness – going with easiest option) (fixed income – related to capex) (signed up to doorstep call because already interested) (persistence in suggesting garage option when roof not viable) Installer? (8) (answered all questions) (scaffolding stayed up long enough for other roof repairs) (personable) (offered installation very quickly after advice) (very little disruption and a problem quickly solved) (installers respectful of property) (very easy installation) (installer advises on quickest and best-known solution when adopter needs rapid response e.g. boiler break down)	(confidence in practices e.g. driving) (has developed spreadsheets to monitor use) (busy – not much time to focus on change) (notices information on wireless monitor) (too complicated to monitor performance and doesn't want to spend time on it) (hadn't thought to change practices) (some changes to practices e.g. running appliances in the day) Installer? (0) Other: FiT lock in with electricity provider

	Intention	Adoption	Use
		Other: institutions (?) water company wouldn't allow water meter because of property configuration	
Non-adopter N=4	Place? (8) (seeing all the PV panels) (enjoying the TTT projects and ethos) (likes the sense of community in a cul de sac – no through traffic) (several projects with similar ethos in the area) (PV panels don't fit with local heritage aesthetic) (neighbours with similar interests) (interest triggered by grants offered) (social norms are different in Totnes e.g. recycling and Surrey) Technology? (9) (more applicable for new builds) (simplicity and using natural resources are good) (cost of running the home – opex) (visual impact) (fit with practices – "I use so little hot water") (FiT income) (projects	Place? (5) (information flows across a cul de sac) (local knowledge and networks for advice) (visibility of energy action) (too many veluxes with loft conversion) (tree shading) Technology? (13) (does it deliver comfort? – woodburner does) (does it heat whole house) (does it deliver appropriate function e.g. looking for small kettle) (capex) (relative capex i.e. it's an extravagance) (very visible) (opex) (reversibility – children had removed radiator reflectors) (real relative advantage - is it the right solution?) (project costs escalate) (does it look good?) (uncertainty about precise function – effect of shading) (opex – source of free timber from	Place? (0) Technology? (1) (long standing – 18 year old boiler) User? (3) (put on another layer of clothing rather than turn heating up) (rejects automation – wants to turn heating on not use controller) (loyalty to longstanding boiler) Installer? (0)

	Intention	Adoption	Use
	cascade into major retrofit – seeking the whole solution) (PV is highly visible) (wind turbines are 'cool', and visually attractive) User? (18) (interest in nature and the environment) (belief that people are too greedy in resource use) (attitudes formed by trusted media sources) (household needs based on demography) (general environmental interest) (dislike of waste) (wants to manage technology, not be managed by it) (awareness of resource use) (climate despair – environmental activism) (comparison with other cultures – this is a stupid way to live) (came in to family money) (slow to take decisions but then stick to them) (likes to be warm) (wants to save money) (TTT approaches didn't fit with life stage) (new into community - likely to join things) (not	work) User? (10) (doesn't believe technology is proven) (trusts selected media sources) (experience with CFLs is that they don't last and has heard about mercury) (waiting for next technology advance rather than committing now) (believes current technology will be passé within 5 years and is wasteful to install now) (aware of price but not too concerned by it) (wants to be sure that this place is long-term, doesn't like to rush) (prefer to trust people rather than research technical data) (expecting better technology soon) (source of free timber from work) Installer? (2) (existing relationship with tradesmen advised against adoption) (builder advised not to adopt)	

	Intention	**Adoption**	**Use**
	a meetings person) (wants to reduce outgoings) Installer?(0)		
Facilitator / Manager N=1	Place? (1) (some capacity in the area) Technology? (0) User? (1) (driven by one or two key individuals in pilot) Installer? (0)	Place? (6) (TTT provided area capacity) (local was a tendering criterion) (desire to increase community cohesion) (tenure) (conservation area and listed buildings) (community support for RE) Technology? (4) (modularity appealing because of funding timescales) (high capital value) (technology cost-benefit – tried to create a value chain) (FiT income enabled different model with loans for low income households) User? (4) (some applicants too risky for loan) (more interested in connecting with neighbours than in the PV) (age profile – younger families too busy for the	Place? (0) Technology? (1) (wireless display and information essential) User? (2) (limited by understanding of what could be done) (habits might be changed by monitoring impacts) Installer? (0)

	Intention	Adoption	Use
		process?) (tenure – not many renters involved) Installer? (0)	
Installer / Surveyor N=1	Place? (2) (word of mouth, local discussion) Technology? (3) (limit in KWp compared to typical consumption) (capital cost) (FiT income) User? (4) (people want to do something, very keen) (lack of interest in science / technology) (expectations of the system) (finances) Installer? (7) (neighbours showing workbook from previous installations) (picking up on user's cues of interest) (not on commission, assessing feasibility) (willing to chat to people)	Place? (6) (shading) (roof orientation) (roof condition) (installer and users in same community) (listed buildings) (weather/season affects ease of installation) Technology? (5) (shortage of inverters) (site requirements – shading, roof orientation) (25 year duration to fit FiT) (exciting – insulation isn't exciting) (technology design interacts with weather/season – panels like sails in the wind, roofs are scorching in direct sunlight) User? (2) (keen to do something, even if sub-optimal) (available finance –	Place? (0) Technology? (3) (wireless monitor cost extra) (inverter usually hidden) (empowers people but doesn't determine their action) User? (4) (understanding of technology and how changing routines can use PV) (interest in science / technology) (interested in downloading data) (monitoring and logging data) Installer?(4) (recommended wireless monitor) (produced commissioning pack which covers practices) (energy awareness) (attention to human interface as well as engineering)

	Intention	**Adoption**	**Use**
	(interpreting technical data into good or bad) (didn't want to say no but also didn't want to put name to sub-optimal installation) (talk about energy generally, not just PV)	determined size of installation) Installer? (4) (advice on feasibility – at the edge of what's suitable) (scaffolding and safe working access) (offer multiple quotes for different size installations) (understood the challenges of working on a roof)	

Appendix 4.1D
Data Summary for REChTarge Case Study

	Intention	Adoption / non-adoption	Use
Adopter N=8	Place? (15) (REcharge scheme loan enabled GT to be considered) (main road location made some technologies unfeasible) (acres of land needed for GSHP) (no mains gas available) (space to plant trees – woodburner) (visibility of roof) (local culture 'careful with money') (support available through council) (no mains gas) (land rented from Lord Dartmouth) (no mains gas, oil tank) (Kirklees council very proactive on carbon reduction) (property construction prevent cavity wall insulation) (planning permission a slight concern) (conservative culture in the area) Technology? (17) (uncertainty over impact) (compatibility with underfloor heating) (possible RHI	Place? (10) (planning permission) (interest-free loan available) (local authority first and showing initiative) (land available for energy or water collection and storage) (local authority innovation) (Leat to be re-excavated) (planning permission) (EA permission) (Yorkshire attitudes – conservative - resistance) (isolation – no gas) Technology? (17) (clarity over pipework – compatibility with other renovations) (noise) (space – additional thermal store) (free energy – reduces bills) (PV fitted around existing ST – compatibility) (grant aided) (inverter availability) (plug and play - straightforward) (shortage of inverters) (ugly) (cost of energy) (shortage of inverters) (FiT income) (visible – positive	Place? (1) (delivery of pellets is difficult) Technology? (16) (FiT constrained by grant aid) (pipework fine, boiler itself difficult) (ignition element and warped feeder tray) (inaccurate design – compatibility with new heating system) (inelegant solution – extra thermal store – loss of space) (comfort temps too low – ASHP) (controller needed upgrading after 4 months – ASHP) (wood pellet boiler never worked properly) (straightforward – PV) (delivery of pellets is difficult) (pellet price increasing) (used more pellets than expected) (PV inverter had to be replaced – fault) (PV – inverter in outhouse so not visible) (micro-hydro

	Intention	**Adoption / non-adoption**	**Use**
	income) (acres of land needed for gshp) (cost – will it pay for itself?) (lower cost than LPG) (affordability – PV not affordable) (possible RHI) (opex – cost of biomass pellets) (no cost) (lower cost than oil) (hot water cylinder taken out so no ST) (heat pumps seem complicated) (romance of self-sufficiency) (capex) (reduce opex) (storage and equipment requirements – biomass too complex) User? (18) (wanted to do home improvements) (family members had had ST in another location and were very happy) (concerns about rising relative costs of fuel) (not a green freak but interested in environment for children's sake) (professional interest as planner) (personal interest and pro-environmental behaviours) (heard through personal social network) (I lean towards the environment side) (family connection with scheme) (mild	– they look good) (compatibility –would the roof be strong enough?) (fitted into cellar retrofit) (pellets need dry storage) User? (12) (ability to work through process) (wants to do something pro-env) (I tend to look on the bright side) (aspiration for self-sufficiency) (pro-environmental attitudes) (technical capacity, interest and skills) (retirement brought more time to act) (very strong place attachment 'jealous of the property') (preference for local sourcing) (understanding of energy systems) (initial lack of understanding of how electricity flows worked) (preference to use known or recommended tradesmen) Installer? (12) (initial installer taken off the job) (confusion over roles of KES and KC and installer) (responding to LCBP deadlines) (good clean workers – worked hard) (knowledgeable) (learning on the job)	control unit tripped) (visibility of panels led to neighbour interest) User? (4) (difficulty finding FiT info – avoid hassle) (willingness to be actively involved in equipment - biomass) (have had to develop knowledge) (wants to tinker – micro-hydro) Installer? (7) (no FiT support) (change of installer contract) (knowledge of new equipment) (manufacturer accreditation for specialist equipment) (knowledgeable and responsive to post installation queries) (quick replacement of inverter) (provided phone instructions to reset micro-hydro controller)

	Intention	**Adoption / non-adoption**	**Use**
	environmental concern) (charge against property is not a great deal for age of householders) (very concerned about env. issues) (acutely aware of water having grown up in arid area) (interested in technology – it's my train set) (originally frugal because poor) (different treatment of opex and capex – compared with car example) (friend's experience with wind turbines) (avoids waste) Installer? (5) (suggested a range of technologies that would be suitable) (initial installer taken off the job) (council way of working) (no choice on installer) (survey incorrect) Other: (3) (lengthy decision making chains and problems accessing scheme management) (long elapsed time to progress) (ease of getting LCBP grant)	(willingness to involve and explain to user) (incorrect specification) (worked hard in awful weather) (professional) (helpful) (micro-hydro – rare expertise – sourced from Shropshire) Other: (1) (delays meant LCBP nearly lost)	
Non-adopter	Place? (3)	Place? (3)	Place? (0)

	Intention	**Adoption / non-adoption**	**Use**
N=6	(local green politicians and activists) (information came from neighbour) (space and dam made property attractive for purchase) Technology? (5) (comfort and warmth of open fire) (cost of fuel) (existing heating system lacked capacity) (reducing bills) (less reliant on scarce fossil fuels) User? (6) (interested in green issues) (limited finance available) (sun, free energy, made sense) (opex cost – FiT income) (technical knowledge from own plumbing business) (interested in green lifestyles) Installer? (2) (advised best solution and brought pictures) (nice chap – took his advice on options)	(conservation area – planning permission) (leasehold not freehold) (national park – planning) Technology? (11) (too costly) (compatibility with current bathroom / plumbing unclear) (too expensive – relative to household income) (impact of ST pipes on warmth in attic unclear) (space needed for GSHP) (would cascade to other things e.g. new flue from basement) (too expensive when plumbing aspects also included) (GSHP attributes – too disruptive to put new piping in walls etc.) (EA permission) (cost) (visibility of ASHP) User? (10) (uncertainty over future finance and technology benefit - PV) (uncertainty over future finance and house value) (difficult to submit planning application) (family circumstances, bereavement etc.) (resistance to capex not opex – willing to	Technology? (0) User? (0) Installer? (0)

	Intention	Adoption / non-adoption	Use
		run 30 year old boiler) (dependent on word of mouth – not confident of own technical knowledge) (household is slow to take decisions) (influenced by neighbour's poor experience of installation) (information overload from options assessment) (thinking long-term and slower solutions) Installer? (6) (nothing happened) (too many people involved in scheme) (didn't trust vagueness of installer and wanted to understand precise implications) (expressed lack of confidence in new technology) (difficulty in finding correct expertise – micro-hydro) (advised that gas is the best option if available i.e. cost focussed not carbon focussed)	
Facilitator / Manager N=1	Place? (0) Technology? (1) (PV's visibility increases its appeal)	Place? (2) (off gas mains) (larger properties, solid stone wall construction) Technology? (4)	Place? (0) Technology? (0) User? (0)

	Intention	**Adoption / non-adoption**	**Use**
	User? (2) (Accessing info though *Guardian, Working Lunch* and political circles) (initially early adopters – very keen on technology) Installer? (0)	(capital cost) (compatible with lifestyle) (FiT increased certainty and reduced drop out) (hot water demand not as high as modelled - cold feed appliances - so less ST) User? (2) (wanted to make the most of tech and boosted £20k from own funds) (older – mortgage paid off) Installer? (1) (provide high quality advice)	Installer? (0)
Installer / Surveyor N=2	Place? (3) (history – mills) (affluence and capital reserves) (what the neighbours are doing – social norms) Technology? (2) (cost – gas has been cheap) (compatibility – ASHP to use PV) User? (2) (user technical capacity) (research -	Place? (11) (age of property) (affluence and capital reserves) (competing claims on land ownership – micro-hydro) (planning) (EA permissions) (lots of goits exist – but clearing them is labour intensive) (planning designations – of architectural interest, conservation areas, listed) (local authority reputation) (space available for GSHPs) (mains gas available) (type of property – solid walls, no insulation, heat	Place? (0) Technology? (0) User? (0) Installer? (0)

	Intention	**Adoption / non-adoption**	**Use**
	whole house thinking – ASHP to use PV) Installer? (1) (recognise and respond to user interests)	pump not worthwhile) Technology? (9) (cost – of connecting with DNO) (lots of goits exist – but clearing them is labour intensive and therefore expensive) (RHI potential) (relative advantage – ST no use if no hot water need) (FiT or export income) (opex – pellets compare with gas cost) (type of property – solid walls, no insulation, heat pump not worthwhile) (ASHP size compatible with mains electricity phasing) (compatibility – losing the airing cupboard) User? (5) (demography – kids drive hot water use) (technically aware and have done own research) (desire to be green) (uncertainty about income) (gender – concern over storage or concern as to technical capacity) Installer? (1) (needs to be clean and tidy, have a schedule, move valuables)	

Appendix 4.1E
Data Summary for ERYC ASHPs Case Study

	Intention	**Adoption / non-adoption**	**Use**
Adopter N=6	Place? (3) (neighbour's experience was positive) (letter from council – grant availability) (no gas mains) Technology? (8) (comfort – storage heaters didn't match needs) (controllability) (cost) (comfort- storage heaters weren't warm in evenings) (cost of LPG – meant reduced comfort) (comfort of storage heaters) (opex cost) (wanted a bit more control over timing) User? (0) Installer? (1) (concern about disruption)	Place? (5) (grant availability) (owner – trust-permission) (no outside space to place unit – boundary at wall) (isolation – 'nobody to help us out') (full grant funding) Technology? (5) (could tech be fitted in an old house?) (high cost of alternatives) (required existing airing cupboard) (compatible with oxygen cylinders) (ugly) User? (13) (PBC with grant) (needs to be supported - advice / encouragement from family – with pro-environment attitudes) (unfamiliar with technology – would have gone with more familiar if comparable price) (don't want to use computer to communicate) (baffled by	Place? (0) Technology? (17) (noisy and windy if outside – but doesn't bother user when inside!) (lost airing cupboard and storage space) (lost airing cupboard storage) (heats whole house – unlike electric fire) (miss the comfort of an open fire – but not the cleaning it!) (can be controlled to meet needs - timing) (neighbour complained about noise – fan changed) (plinth needed to be renewed) (halved opex) (easy to control – no action needed) (whole house heating) (froze up in cold winter) (stopped working in Oct '11) (froze in winter – will now leave system on when away) (froze up in cold winter) (costs more than expected) (immersion heater still not

	Intention	Adoption / non-adoption	Use
		how technology works) (desperate to find ways to reduce cost) (capacity to take risks where outcome is unknown) (wants independence) (invalid so needs to be warm) (wanted to understand more) (technical knowledge – retired hating engineer) (oxygen cylinders limit choice – no open fires) (queried if drainage gully is deep enough) Installer? (15) (local builders advice) (came on day planned, quick, made a mess, cleaned up after) (October – doors open all day and late – very cold for inhabitants) (checked plan for radiators before confirming installation) (very clean) (tidied up) (ran pipe neatly along beams) (disruptive couple of days) (carried out while adopter was away) (very brief commissioning handover) (used adopter's professional experience to design pipe runs) (flood overnight during installation because of faulty immersion heater) (very mucky)	working) User? (12) (likes routine of hot water availability) (didn't fully understand commissioning instructions) (prefers not to control using thermostat as advised because it doesn't seem right to adopter) (likes timer control) (doesn't notice noise) (notices but is not disturbed by noise) (likes the noise) (needs effort to understand but is happy to try) (asks friends to help fix problems) (changes habits – will now leave system on while away) (notices noise but copes with it) (shocked by first bill) Installer? (6) (provided a leaflet but little discussion) (recalled to explain how immersion heater worked) (telephone assistance when hot water pipe froze) (telephone assistance when system froze) (out of contract when problem arose – programme manager helped find

	Intention	Adoption / non-adoption	Use
		(cut lino jagged when moving thermostat) (messy and required redecorating because of radiators)	alternative contractor) (came out with blow lamp to defrost frozen systems)
Non-adopter N=0	No data	No data	No data
Facilitator / Manager N=3	Place? (7) (lots of properties -27% - off gas network) (cannot be connected to gas network because onshore pipeline pressure too high) (strong networks – fire, health, social services…) (large 1960s estate needing retrofit) (councillor priority because of ward constituents' priorities) (council brand is positive and trusted) (publicity means that council is known to be supportive) Technology? (4) (oil and LPG costs increasing) (doesn't look nice on first sight) (evidence of cost reduction) (longevity of equipment) User? (7)	Place? (10) (planning) (building control officers had special training) (electricity supply rating) (rurality) (building type) (high IMD) (publicity means that council is known to be supportive) (IMD) (extent of gas grid) (DNO attitude) Technology? (12) (practicalities of drilling boreholes prevent GSHP installation) (requires Building Control notice) (longevity) (ease of maintenance) (split system preferred to minimise freezing risk) (visibility – people notice them) (not intuitive) (difficult to predict cost savings) (GSHPs difficult to implement accurately at scale) (ASHPs likely to achieve unit price reductions) (most retrofit projects require bespoke	Place? (1) (neighbours more likely to complain about noise than adopters) Technology? (6) (teething problems with noise) (prioritise heating over hot water in cold weather) (demands more than an on/off from the user) (radiators not as hot as expected) (split system more resilient to low temps) (very dependent on correct antifreeze levels) User? (7) (fixed income) (habit – might not want whole house heating) (habit – bathing routine with social services) (capacity to make changes) (setting controls incorrectly) (expectations – hot

	Intention	Adoption / non-adoption	Use
	(reassured by real local examples) (ability to manage a technology which requires effort e.g. open fire) (hassle and inconvenience) Installer? (2) (local knowledge of how far gas network extends) (went to see installed units for herself)	solutions and new pipework) (doesn't require user intervention e.g. fetching fuel) User? (7) (most vulnerable don't come forward – so hard to spend cash!) (responded to trigger in change in personal circs) (need to trust facilitator) (needs to be in a position where thinking about a new system anyway) (wants to see one) (may not want disruption / redecoration) (may not be able to access fuel independently – automatic nature of ASHP is appealing) Installer? (6) (ability to take opportunities – like installation before adopter is discharged from hospital) (private sector less likely to be concerned with public goods) (initial scepticism) (tries to make commissioning checks simple) (try not to oversell) (MCS accredited installers tended to be much more expensive	radiators, hot water) (DIY might not replace antifreeze) Installer? (5) (needed to keep revisiting to assess noise) (developed noise 'attenuation kit') (can't advise on tariff) (insufficient antifreeze at installation to save money – meant systems froze) (responded to calls about controlling the system)

	Intention	Adoption / non-adoption	Use
		than more local heating companies)	
Installer / Surveyor N=2	Place? (2) (rurality – limited options) (every house different – even if same design originally) Technology? (4) (size of unit) (need an airing cupboard inside) (cleaner) (more control) User? (4) (familiarity with technology) (want to talk to someone and see kit, not read info) (want less physical work) (privacy – didn't want strangers in house) Installer? (5) (time taken to educate / influence was quite off-putting) (needed to see installed units) (like the diagnostic controller and manufacturer support from one manufacturer) (not selling) (bespoke design every time)	Place? (5) (properties close together – noise acceptable) (flood risk – wall mounting) (rating of power supply) (planning) (elevation orientation) Technology? (8) (provided comfort) (controllability) (ease of use) (noise) (cheaper) (needs cupboard space inside) (south and west elevations preferred) (compatibility – biomass would require chimney networks reinstating) User? (1) (concerned about impact of power cuts) Installer? (5) (required training) (happy to diversify a bit) (scheduled 4 day installation) (offered electric fire for visual comfort) (on a learning curve)	Place? (1) (planning limiting elevation for mounting) Technology? (11) (provided comfort) (controllability) (ease of use) (noise) (radiator and water temp might be lower than anticipated) (drip condensate) (much cleaner) (noise) (no financial benefit if more comfort taken) (freezing in cold weather) (frozen in cold weather) User? (4) (expectations – "not used to the low output") (changing cleaning routines) (changing routines for programming heating – taking more comfort) (diluted antifreeze by taking radiator off) Installer? (4) (correct antifreeze needed at commissioning) (would like frost

	Intention	Adoption / non-adoption	Use
			protection) (repeated visits for noise assessment and solutions) (out for many late nights defrosting)