The rationale for retrofit: A multi-level, interdisciplinary perspective on the energy efficient retrofit of existing residential buildings.

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Publications

This thesis incorporates three academic articles; one of which has been published, one is accepted with revisions and one is yet to be submitted.

- Kerr, N., Gouldson, A., Barrett, J. 2017. The rationale for energy efficiency policy: Assessing the recognition of the multiple benefits of energy efficiency retrofit policy. Energy Policy, 106, 212-221.
- Kerr, N., Gouldson, A., Barrett, J. 2018. Holistic Narratives of the Renovation Experience: Using Q-methodology to improve understanding of domestic energy retrofits in the United Kingdom. Energy Research & Social Science, 42, 90-99.
- Kerr, N., Gouldson, A. 2018. Retrofit's Public and Private Balance of Payments: comparing the investment case for energy efficient retrofit of households and government. Submitted to Energy Policy March 2018.

As sole / lead author on these publications, I was responsible for developing the articles' hypotheses, and designing the methodology. I was also solely responsible for data collection and analysis, as well as writing and revising the manuscripts throughout the academic peer review process. The co-authors provided guidance throughout the process and feedback on draft manuscripts.

Rationale for alternative thesis format

This thesis set out to build on existing research experience related to the micro- and macro-economics of energy efficiently retrofitting the UK housing stock. In keeping with the demands of research related to the complex, joined-up problems of modern energy systems the research was specifically structured to develop an interdisciplinary perspective. Through discussion with the thesis' supervisors it was considered important that the thesis was not only interdisciplinary and mixed-method but multi-level considering different stakeholders in the area of home retrofit. Two key stakeholders – national government and private households - were identified as of fundamental relevance to the topic and empirically and disciplinarily distinct research plans were developed for each. A third distinct research plan was developed that was of relevance to both stakeholders.

Due to the interdisciplinary intent and the distinctiveness of each research plan the overall PhD lent itself to the development of academic articles for each piece of work. Through discussions with the project's supervisors it was deemed appropriate to present the thesis as stand-alone academic articles, and to bring together their findings in the back material of an alternative format thesis.

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This research has benefited greatly from the guidance of my three supervisors. I had worked alongside Professor Andy Gouldson for several years prior to this PhD research and the content of this thesis is to a large degree informed by these experiences. Professor Gouldson's thoughtful, pragmatic and open approach to research and work in general is a model which, I imagine, will influence the way that I work for many years to come. I also had some professional experience with Professor John Barrett prior to this research and was very pleased to be able to spend more time discussing the multi-faceted problems of the 21st century energy system with John on a regular basis. Professor Andy Brown also provided an additional interesting and useful interdisciplinary political and economic perspective on my research. I am also grateful to colleagues in the School of Earth and Environment with whom I had many useful discussions over the years; notable mentions go to Lucie Middlemiss, Ross Gillard, Jamie Van Alstine, Dan O'Neill, Julia Steinberger, Martin Dallimer, Claire Bastin, Alice Owen, Rebecca Howard and Steve Orchard.

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Abstract

The research in this thesis ultimately emanates from the international efforts to mitigate the impacts of anthropogenic climate change. The unprecedented international effort to transition societies to a low carbon future will have wide ranging political, social and economic consequences. The nature of the modern, complex, joined-up world entails that changes in any particular domain will have consequences that are wide-ranging, and often intangible. This thesis entails three distinct empirical pieces of research in relation to a key facet of many national climate mitigation efforts, namely the energy efficient retrofit of existing residential buildings. It develops a multi-level, interdisciplinary perspective that incorporates three different views on the rationale for retrofit. At the macro, government level the research considers the multiple benefit framing of energy efficiency in relation to the rationale for retrofit policy. Using the multiple streams theory of policy formation, descriptions of retrofit policy rationale in 4 national contexts are developed with the implications of potentially varying policy rationales considered. At the household level retrofit routinely takes place alongside general home renovations in a process that is connected to a wide variety of influences and background conditions. The micro-level research uses Q-methodology to develop holistic narratives of the home renovation process that provide a more heterogeneous understanding of households that have the potential to retrofit. A third article then combines the macro and micro-levels to consider the comparative economic rationale for government and households to invest in retrofit, considering the distributional properties that are a feature of many climate policy interventions. Finally, the thesis develops an integrated, interdisciplinary viewpoint by considering the political, social and economic perspectives on the rationale for home energy retrofit in conjunction.

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Glossary

ACF: Advocacy Coalition Framework

BE: Behavioural Economics

EE: energy efficiency

EPC: Energy Performance Certificate

IA: impact assessment

IEA: International Energy Agency

MS: Multiple Streams

NPK: New Production of Knowledge

NPM: New Public Management

RCT: Rational Choice Theory

ROI: return on investment

PAYS: pay as you save

PE: Punctuated Equilibrium

PNS: Post Normal Science

PT: Practice Theory

Q: Q-methodology

VAT: value added tax

1. Introduction

The background to this PhD thesis is roughly 3 years' research on the economic impacts of carbon emission reduction options. The 'Economics of Low Carbon Cities' (ELCC) projects involved disaggregating city regions into different economic sectors, and assessing the carbon savings, and possible economic costs and benefits of a variety of different measures. Sectors included industry, transport, commercial buildings and, the sector of particular interest to this research, residential buildings. The low carbon measures that were modelled for residential buildings, people's homes, were predominantly energy efficient retrofit measures. Retrofit measures, in theory, reduce carbon emissions and generate economic returns concurrently, by reducing a home's demand for energy. The measures considered in the research varied greatly in terms of their economic costs and benefits, and their carbon savings. Some options involved considerable carbon savings and a return on investment in a few years, while the savings of other options would ultimately never cover the cost of upfront investment. Data for the performance of measures was taken from the micro, household level and aggregated to produce macro, city level results. The residential buildings sector was of particular interest because it presented a list of low carbon measures that were relevant to every member of society. A large-scale decarbonisation of the UK is likely to entail fundamental changes to the way that the vast majority of people live. The personal, intimate environment of home presents the most visceral of case studies as to how people might react to the possibility of current and future decarbonisation changes.

Research that I was involved with after the ELCC projects entailed the ex-post evaluation of the savings from energy efficient retrofit schemes in residential buildings, and the modelling of revolving fund investment in retrofit schemes. In keeping with the ELCC research these projects also utilised the principle that investment in carbon reduction can also involve a reduction in energy bills, and thus generate an economic return on low carbon investment.

Making the case that there was a dual benefit from these decarbonisation options - carbon and cost - was intended to improve the case for action on climate change.

Whilst producing research outputs that communicated the economics of decarbonisation I was aware of research that was critical of efforts to frame environmental change in terms of its economics, arguing that it was an inappropriate means of conceptualising the issue, it had limited ability to affect change, or that it could ultimately prove counter-productive if the economics were not favourable (Ackerman, 2008; Evans *et al.*, 2012). From my research experience I considered there to be value in communicating the economics of low carbon measures, but for my PhD research I wanted to expand my perspective on the process of low carbon and general energy system transition, to incorporate different scientific disciplines and methods, and new perspectives.

There is an increased demand for, and production of, interdisciplinary work in many different areas of research. Interdisciplinary approaches to research are seen as representative of a shift toward scientific investigation that is more applied to 'real-world' problems (Nowotny, Scott and Gibbons, 2001; Barry, Born and Weszkalnys, 2008), and from an acceptance that the complex issues of the modern joined-up world are not most effectively addressed by mono-disciplinary approaches (Max-Neef, 2005; Turnpenny, Lorenzoni and Jones, 2009).

The research in this thesis takes a multidisciplinary and multi-level approach to a critical aspect of 21st century energy system transition, namely the energy efficient retrofit of residential buildings. It uses the framing of energy efficiency (EE) as having *multiple benefits* to analyse the rationale for retrofit of two of the key stakeholders in energy systems transition, the government and private households.

Employing both qualitative and quantitative methods the research comprises three empirically distinct pieces of work. Applying theories of the policy process, chapter 2 entails a *macro, government level* analysis focused on the perceived multiple benefits of retrofit, the degree to which these are recognised within the overall rationale for retrofit policy and the extent to which variable rationales may affect policy. In chapter 3 the *micro, household level* analysis takes a broader view of the rationale for retrofit and develops narratives of household renovation experiences, which incorporate all of the background conditions, influences for and against household action on retrofit. Chapter 4 uses data on the economic cost of and returns from action on retrofit, to perform *a comparative analysis* of the economic case for investment in retrofit at the macro and micro levels. Chapter 5 considers the findings of each piece of research in greater detail and then sets out the combined outcomes of the thesis.

1.1. Research framing and philosophy of science

As set out the intent of this thesis is to develop a multi-level, interdisciplinary perspective on a critical facet of many national low-carbon, energy system transitions - home EE retrofit. This intent emanates in part from the background of the researcher and in part from the nature of the topic i.e. climate change and energy system transition generally, and the multiple benefit framing of home EE retrofit specifically.

1.1.1. New Production of Knowledge

There is an increased demand for, and production of, interdisciplinary work in many different areas of research. Such changes are intrinsically related to a belief that the complex problems of the modern joined-up world are not most effectively addressed by conventional, mono-disciplinary approaches to research (Max-Neef, 2005; Turnpenny, Lorenzoni and Jones, 2009). The increased interest in interdisciplinarity has been characterised as a shift from Mode-1 to Mode-2 science or as the New Production of Knowledge (NPK) (Gibbons *et al.*, 1994; Nowotny, Scott and Gibbons, 2001). Mode-1 science is regarded as being relatively autonomous from the social issues of the time, as taking place within traditional academic disciplinary boundaries, as being subject to the established peer review process and often as lacking direct, purposeful application to ‘real-world’ problems. The perceived shift to Mode-2 is related to a belief that as the products of scientific innovation have an increased level of interaction and influence on human society, the means of knowledge production cannot, and should not, remain autonomous from their social context (Barry, Born and Weszkalnys, 2008). It is characterised as being transdisciplinary, socially accountable and reflexive, as taking place in a mix of academic and non-academic venues and as being subject to novel forms of quality assessment. The NPK characterisation of change is contested, with some of the trends upon which the perceived shift is based i.e. that transdisciplinary research constitutes a significant part of modern science, or that university researchers are increasingly socially reflexive, subject to dispute (Hessels and Van Lente, 2008).

The research in this thesis is distinctive from many of the characteristics of NPK; it involves peer-reviewed research, and it takes places in an academic context. It does, however, resonate with some of the perceived features of NPK; it is focused on a particular ‘problem’ and it also seeks to “incorporate multiple views” on this problem (Hessels and Van Lente, 2008).

Alongside NPK there are multiple, additional interpretations of a perceived changing scientific paradigm (Hessels and Van Lente, 2008). This thesis is also related to the model of ‘strategic research’ that entails descriptive research, but which explicitly intends to have prescriptive implications for policy. It is differentiated from Mode-2 by its intent to develop ‘basic’ research as opposed to directly ‘applied’ research i.e. developing a base of knowledge that is recognised as of relevance to a current or future problem, but with a distance maintained between the researcher and the application of their research (Rip, 2004). Research that relates to climate change in general is seen as an example of ‘post-normal science’ (PNS) (Turnpenny, 2012). Emanating from policy-relevant environmental research, PNS relates to issues where the “facts are uncertain, values in dispute, stakes are high and decisions urgent” (Funtowicz and Ravetz, 1993). This model is based on an acceptance of the limitations of rational, empirical decision making, and characterises ‘normal science’ as “assuming that problems can be divided into small-scale problems that can be handled without questioning the broader framework or paradigm” (Hessels and Van Lente, 2008). Whilst having the needs of policy-makers in mind PNS also emphasises the importance of public participation and an “extended peer community” (Funtowicz and Ravetz, 1993).

1.1.2. Interdisciplinary research

Interdisciplinarity is an unmistakably ‘fuzzy’ concept, not least because of the difficulty of drawing boundaries around single disciplines. Different disciplines are associated with distinct sets of methods and concepts, as well as often with particular ‘world-views’. It is argued that disciplinary boundaries allow for efficiency of communication and operation, but ultimately can put limits on the kind of questions that can be addressed (Bruce *et al.*, 2004). Interdisciplinary research projects or communities are associated with the identification of research questions from outside of traditional academic boundaries or as being ‘problem-driven’ (Bruce *et al.*, 2004; Winskel, Ketsopoulou and Churchouse, 2015).

Efforts to move knowledge production beyond the realms of single disciplines and to enhance its connection to the wider world have resulted in a wide variety of descriptions as to what interdisciplinarity entails. Interdisciplinary research in its simplest terms is thought to involve “research that transgresses traditional disciplinary boundaries” (Siedlok and Hibbert, 2014). The ultimate level of integration between disciplines is dependent on the context of the research or the problem that is to be addressed. A single project is more likely to result in ‘knowledge exchange’ as where a more long-term research community has the potential to involve some form of ‘knowledge creation’ (Siedlok and Hibbert, 2014).

The spectrum of interdisciplinary integration is thought to roughly begin with multidisciplinarity - with two or more disciplines each addressing research questions related to a common issue but still working using their own existing methods and framings (Siedlok and Hibbert, 2014). Whilst multidisciplinary research is thought of as entailing “borrowing and co-operation” (Siedlok and Hibbert, 2014), an interdisciplinary approach is thought of as being “additive rather than integrative” and as seeking some form of synthesised outcome (Pellegrino and Musy, 2017). Transdisciplinarity is thought of as a yet more integrated approach, involving more of a “fusion” of disciplines that can ultimately result in the emergence of new disciplinary organisations and communities. It is also often associated with the integration of non-academic stakeholders, in order to further improve its applicability credentials (Lyall, Meagher and Bruce, 2015). With respect to the field of energy research, Sovacool (2014) considers academic journal articles to be interdisciplinary according to their authorship i.e. if “one author that had training in at least two conventional disciplines”, if an author has “a self-identified interdisciplinary position” or if the article involves “at least two authors holding positions in at least two separate disciplines”.

A ‘physical-technical-economic model’ is thought to have been dominant in energy efficiency policy making and research in the Europe and the United States for some time (Lutzenhiser and Shove, 1999; Lutzenhiser, 2014). Energy research at the level of UK government has also recently been acknowledged as being weighted toward the engineering and economic disciplines (Cooper, 2017). In response to this perceived hegemony there has been a developing interest in a fuller interdisciplinary integration of the social sciences within energy research.

Interdisciplinary research in the field of energy consumption and buildings (and the energy field more generally) is thought to have mainly related to ‘socio-technical’ approaches (Pellegrino and Musy, 2017) with a desire to “remember the people” in research and policy

(Gram-Hanssen, 2014b). The socio-technical perspective with respect to energy systems seeks to incorporate the complexities of human agency and social structures (Geels *et al.*, 2017), and the view that “technical change is an unremittingly social … process” (Shove, 1998). Some authors feel that making a clear distinction between the technical and social “makes little sense” (Shove, 1998), and that it would be more appropriate to see behaviour and technology as integrated in a socio-technical ‘co-evolution’. Pellegrino and Musy (2017) outline four main “families” of interdisciplinary research with respect to energy use and buildings, with all of these groups in some way involving research related to the interaction of the social – building occupants – and the technical – the technologies or the building itself.

1.1.3. Critical realism

As a result of the interdisciplinary, multi-level intent, this research is drawn to a critical realist philosophy of science. The views of critical realism stem from the rejection of what is termed the ‘epistemic fallacy’ – that the study of being (ontology) can be reduced to the study of theories or proof of knowing (epistemology) (Bhaskar, 2010). Science has tended to focus on that which can be understood via a positivist lens; that in closed system, from experience we are able to predict that event 2 will always follow event 1. The open systems of the world, however, do not involve closed laboratory conditions and thus reality does not typically conform to any predicted conjunction of events (as social history repeatedly shows us). Critical realism acts to “remind us of the enormity of the unknown and unproven” and that “the world does not correspond to our knowledge of it” (Cornell and Parker, 2010).

A key facet of this approach to research is the observance of epistemological relativism or that any and all knowledge is relative to time, place and general context. As a result of this position, critical realism is identified as a philosophical position that is somewhere between positivism and the full-blown social creationism of a constructivist epistemology. As knowledge is relevant to context, all knowledge of the world results from the ontological position taken; any perspective on reality modulated by the ontological lens through which it is viewed. It relates to an interpretivist research position that denies the possibility of complete research objectivity and draws meaning from culturally and historically situated subjective experience.

It is “inclusive” when it comes to theoretical perspectives and entails a belief that multiple theories (metatheories) can co-exist simultaneously (Bhaskar and Danermark, 2006). A common analogy of such logic relates to the human body, which depending on the ontological position taken is made up of atoms and molecules (physical), of organs and tissue (biological), or as a collection of memory and experiences (social science) - the world is stratified into a structured and differentiated ontology. Due to the inherently contextual nature of all knowledge production the ‘realism’ stems from the view that there are multiple, legitimate ways of viewing and interpreting the world that do not need to necessarily be in conflict.

A critical realist philosophy recognises that due to the inherent complexity of open social and economic environments there are profound limitations on the abilities of natural scientific methods to investigate causal relationships/phenomena (Lawson, 1997; Steele, 2005). Gradually, however, some generalisations can be built upon the basis of highly contingent, contextual evidence. The critical realist position on the relationship between theory and observation is similar to that of Karl Popper (Popper, 1992) that “theory without experiment is empty and experiment without theory is blind”. Theories are needed to make sense of observations, while observations are able to gradually limit the scope of theory and allow knowledge to exist on shaky but possibly satisfactory grounds (Pawson, 2013b).

The perceived techno-economic paradigm within energy research is related to a perceived “privilege” of disciplines which work in more quantifiable, predictable terrain, with “traditional philosophies of science taking physics as their exemplar” (Cornell and Parker, 2010). Critical realist philosophy with respect to climate change talks of the “radical inadequacy” of approaches that do not address the open and connected aspects of the socio-ecological system (Cornell and Parker, 2010).

1.1.4. Summary

The subject of this thesis is the multiple benefit framing of the energy efficiency retrofit of buildings. The perceived multiple benefits of retrofit cross the domains of environment, health and economics (see section 1.2.4.). Interdisciplinary research in the energy sector has historically tended to entail the application of broader social sciences alongside the perceived more embedded technical and economic perspectives. This research intends to gain a novel multi-level, interdisciplinary perspective on the rationale for retrofit of government and households. This is achieved by considering theories of public policy-making in order to assess the rationale for retrofit policy of governments. To draw on theories of behavioural research for the micro level household perspective of home renovation with respect to retrofit. The final piece of empirical work entails a comparative economic assessment on the case for retrofit at the macro and micro levels.

The research is most properly positioned at the multi-disciplinary side of the interdisciplinary spectrum, as each piece of research will stay within the boundaries of a particular discipline i.e. political science (specifically policy studies), social science (specifically behavioural research) and economics (macro cost-benefit analysis). The discussion section will endeavour to achieve a greater level of disciplinary integration, by reflecting on and comparing the findings of each piece.

1.2. Research background

1.2.1. Energy efficiency and energy system transition

As global demand for energy services continues to rise, and the environmental consequences of current models of energy provision intensify, systems of energy provision face calls to become more environmentally sustainable and socially equitable, whilst remaining reliable and secure. This set of concerns is often referred to as the energy trilemma (WEC, 2013; IEA, 2016c). The political, economic, social and technological distinctiveness of national contexts, mean that there are a variety of nationally specific approaches to energy system transition. The nature of the risks posed by anthropogenic climate change, however, mean that a degree of coherence is required with an *international* energy systems transition (UNEP, 2014). The challenge of transitioning to a low carbon energy system whilst maintaining security of supply and making access to energy services more equitable have led some to suggest that the energy sector has not been so prominent on the political agenda for several decades (Skea, Ekins and Winskel, 2011). The multiple objectives of system transition can be difficult to reconcile, and can compete for political and economic capital, with the ultimate prioritisation of objectives subject to social and economic preferences (Hughes and Urpelainen, 2015).

A wide variety of different options could potentially contribute to the energy provision system of the future. The different possible combinations of option give rise to the idea that there are multiple possible transition pathways (Foxon, 2013). Decision-making with respect to energy system transition is characterised as involving significant uncertainties; uncertainty related to the numerous future options, and to the system more broadly i.e. energy prices and political and social commitment etc. (Watson *et al.*, 2015).

Each future energy system option has implications for each of the multiple objectives of energy system transition. For example, a particular option may positively affect the objective of environmental sustainability by lowering carbon emissions, but negatively affect the issue of equitability by increasing the cost of energy. Another option may involve the utilisation of a relatively reliable and secure domestic energy source, but ultimately result in higher levels of carbon emissions.

This thesis addresses one of the fundamental options of modern energy system transition pathways, namely energy efficiency. Energy efficiency - or using less of the available primary energy resources - oil, gas, hydro, wind, solar etc. - to achieve the same levels of energy services - heating, lighting, transportation etc. – can be viewed as a means of at least partly addressing *all of the objectives* of the future energy system (Mackay, 2009; IEA, 2014a). Energy demand reduction via efficiency improvements is, alongside the decarbonisation of energy supply, one of the two key tenets of long term low carbon transition (CCC, 2015b).

How efficiently energy services are achieved from available primary energy sources is an issue that is not new to the political agenda. The oil crises of the 1970s moved EE firmly onto the agenda of many countries (DECC, 2012a; Mallaburn and Eyre, 2013). In the 21st century it has been suggested that measures seeking to address the efficiency of energy use and the general demand for energy, will increasingly move from being “passive to active” (Helm, Wardlaw and Caldecott, 2009). The International Energy Agency (IEA) has in recent years tried to emphasise the importance of EE to its member states – it has gone from framing EE as a ‘hidden fuel’ to labelling it as the ‘first fuel’(IEA, 2014b). This framing is justified on the basis of estimates that investment in EE since the 1970s have avoided an amount of energy use greater than the contribution to energy supply of any single fuel source i.e. oil, gas, coal etc. (IEA, 2013). The emphasis on EE has seen annual ‘Energy Efficiency Market’ reports (IEA, 2013, 2014b) joining the more established market reports for coal, oil and gas (IEA, 2006, 2011, 2012). The IEA currently assert that EE is “the key to ensuring a safe, reliable, affordable and sustainable energy system for the future” (IEA, 2017).

This increased focus on EE is in part due to the perception that historically demand-side energy policy options have been overlooked in favour of supply-side options (Verbruggen, 2003; Lazar and Colburn, 2013) with a resultant bias toward investment in energy generation over energy demand reduction (IEA, 2015). The IEA estimate that with existing levels of policy support, two thirds of economically viable EE potential will remain un-tapped by 2035 (IEA, 2014a). This perceived undervaluing is attributed to a variety of EE's inherent features, including, the nature of its measurement i.e. measuring a negative value (energy savings), the resultant level of return on investment being considered very uncertain, and to the potential for a variety of related rebound effects (Keay, 2011; Sorrell, 2015).

It has been observed since the 19th century that using available energy resources more efficiently, is not necessarily an effective means of reducing overall energy demand (Alcott, 2005). The principle of EE rebound, or the Jevon's paradox, observes that improving the efficiency of energy use can work primarily to move the source of the energy demand, rather than reducing the overall level of energy used (Keay, 2011). Energy efficiency rebound can relate *directly* to the energy service to which the efficiency improvement is applied, resulting in lower energy savings than predicted, due to a higher level of energy service being provided than was previously. Or it can apply *indirectly* with EE improvements in the production or use of a particular good or service, resulting in higher energy consumption in relation to a different good or service (Sorrell and Dimitropoulos, 2007).

Rebound is most commonly considered with respect to a change in the behaviour of the energy user, although it is at times also used with respect to sub-optimal performance of the efficiency technology, resulting in lower than expected savings, an occurrence more commonly reported as a performance gap (Sanders and Phillipson, 2007; Gram-Hanssen, 2014b). When considering the level of change that results from efficiency efforts - saving and/or rebound – the modelled baseline activity and the modelled forecast change are as important as the follow-up measurements of actual activity, when assessing impacts (Imam, Coley and Walker, 2017). The many different ways of measuring and interpreting rebound – direct, indirect, user, technology - inevitably can lead to quite different understandings and estimates (Galvin, 2014a). Despite the complexity it is ultimately important to be aware that when considering EE, one is not just dealing with energy savings, but with *multiple rebounding impacts.* Macro-level analyses that assess both direct and indirect rebound implications suggest that national EE improvements can lead to absolute energy demand reduction but not necessarily within all types of economic structure (Brockway *et al.*, 2017).

The EE option has been consolidated within many national energy system transition plans via the use of legislated targets. At the European Union level, EE is a "key element on the EU's political agenda" (Egger, 2015), with EU countries regularly setting targets for EE within their climate change mitigation strategies. The EU itself has an EE target of 20% less energy use than its forecast level of energy use for 2020, with talks ongoing about the level of the 2030 target. As the 2020 forecast is based on increasing historical trends this target may not actually require a reduction in energy use. Some countries are more ambitious, with Germany for example, having a target of 20% set in terms of an actual reduction in energy demand (Buchan, 2012).

1.2.2. Energy efficient retrofit of existing buildings

Governments planning for the challenge of energy system transition will typically disaggregate energy activity into sectors. The 'buildings' sector, whether they are lived in – residential - or worked in – public and commercial - is the location for a large proportion of our current energy services. With the vast majority of our lives in the 21st century taking place indoors (Klepeis *et al.*, 2001) it is unsurprising that worldwide it is estimated that around a third of all energy use is associated with activity in our building stock (IPCC, 2013). This energy use translates into carbon emissions either directly through fuel use in buildings, or indirectly through the use of electricity in buildings. Direct and indirect emissions from buildings combined, are estimated to account for around 30% of global GHG emissions (UNEP, 2009). In the UK the domestic and service sectors (a rough proxy for buildings) accounted for 45% of all energy use in 2016 (BEIS, 2017a) and around 40% of total UK GHG emissions in 2015 (BEIS, 2017b). Residential buildings - accounted for about 30% of energy and 22% of emissions in the UK in 2015.

As with energy use more generally it was around the time of the 1970's oil crises that the energy performance of buildings began to be more heavily scrutinised. Around this time many countries, began to introduce regulations for new buildings that included provision for how efficiently they used energy (Jager, 1983; McDonnell and Sinnott, 2010; Buchan, 2012; Howden-Chapman *et al.*, 2012).

It has been estimated that in some countries – typically those with longer histories of industrialisation – the currently existing building stock will constitute the majority of the future building stock for many decades to come – in the UK it is estimated that between 66% - 80% of the buildings that will exist in 2050 have already been built (Royal Academy of Engineers, 2010; Schröder *et al.*, 2011; Kern, Kivimaa and Martiskainen, 2017). Despite older buildings not necessarily being less energy efficient than their modern equivalents (including those that were not subject to mandatory energy performance regulations), the advent of energy performance regulations for new buildings has, in the UK at least, seen an improvement in the energy performance of the overall building stock (Dowson *et al.*, 2012).

The expected longevity of many of our existing building stocks – a result of low building demolition and/or construction rates – means that attempts to change our current systems of energy provision, must consider the energy performance of the building stock that is currently standing. Energy efficiently retrofitting the existing building stock is, therefore, a topic that has reached the political agenda of various countries around the world growing in prominence since the turn of the century (Mallaburn and Eyre, 2013).

Energy efficient retrofit measures can be divided into passive – those that do not require the use of energy – and active – those that do require some energy input but that use that energy more efficiently (Roberts, 2008; Weiss et al., 2012). Passive measures typically address the building envelope or fabric i.e. walls, rooves, doors, windows etc., using insulation or glazing materials to lower a surface's u-value. Active measures relate to a building's heating system e.g. a more efficient boiler, or electrical appliances.

Macro-level, international analyses that have considered the technological and economic feasibility of retrofitting existing buildings frequently conclude that much of the technology is well established, and that it often demonstrates a cost-effective economic case for implementation (HM Government, 2009; UNEP, 2009; EC, 2011; IPCC, 2014). In energy system transition pathways, the buildings sector is often seen as of primary importance in the early stages of transition. This is due to its relatively large overall contribution to energy use and carbon emissions, *and* that the possible approaches to reduction in the sector, are often considered "proven and commercially available technologies" (Enkvist, Nauclér and Rosander, 2007; Gardner and Stern, 2008; UNEP, 2009; Kesicki, 2010). This state of measure and technology development is not considered to be the case in other potential abatement sectors such as transport, where technological advances are deemed necessary to achieve emissions reduction targets (IPCC, 2013).

As with EE more generally the extent to which retrofitting buildings actually results in energy savings and thus carbon emission reduction is a regular subject of analysis. In recent years assessments have taken an empirical look at what the level of direct and indirect rebound might be in relation to building retrofit (see Chitnis and Sorrell, 2015; Chitnis et al., 2014, 2012; Druckman et al., 2011 for a developing view on the rebound effect from retrofit in UK homes). With gas and electricity in the UK having relatively high carbon intensities per unit expenditure, the indirect carbon rebound from retrofit is unlikely to exceed the carbon saved (Chitnis and Sorrell, 2015). The concept of a pre-bound effect – the idea that the estimates of energy use before a retrofit takes place are too high and thus any measurement of energy savings may be too great (Sunikka-blank and Galvin, 2012) – reinforces the importance of correctly modelling baselines, when forecasting change (Imam, Coley and Walker, 2017).

Ex-post evaluations of actual retrofit schemes have become more common in the UK in recent years. Some deep energy retrofits that seek to achieve larger energy savings via a 'whole-house' approach have seen energy saving results below what was estimated (Gupta *et al.*, 2015; Gupta and Gregg, 2016). While some retrofit programmes targeting the 'lower hanging fruit' of cavity-wall and loft insulation, and the replacement of older gas boilers with more efficient condensing versions, have had reported energy savings that are in line with some predictions (Adan and Fuerst, 2015; P Webber, Gouldson and Kerr, 2015). A systematic review of the evidence of energy savings from different EE programmes by Wade and Eyre (Wade and Eyre, 2015) concluded that the peer-reviewed literature offers no clear picture but that estimates of energy savings from government funded investment programmes for retrofit range from 44% - 75% of the theoretically possible savings.

As highlighted, EE can be considered a means of at least partly addressing the multiple objectives of energy system transition. Retrofit is regularly advocated as a means of allowing households to live in warmer, healthier conditions (Boardman, 1991; Milne B., 2000). Households that receive a home retrofit that were previously considered to be living in 'fuel poverty' or an uncomfortably cold home are likely to 'take' some of the potential energy saving from the retrofit and live in a warmer, more comfortable home (a well-documented example of rebound). By making warmth easier to achieve, retrofit is considered as one potential means of improving the equitability of the energy system. Equitability in terms of energy provision is subjective and is considered differently in different jurisdictions. The identification of an issue such as fuel poverty is a political and social acceptance that energy provision is unequitable. It has been argued that retrofit is increasingly becoming the politically preferred means of addressing fuel poverty in the long term (Middlemiss, 2016). It has also been suggested that energy efficiency more generally can affect the security of provision within future energy systems. This has been observed with respect to historical efforts at energy security in the USA (Yergin, 2006), and as having the potential in other national contexts in the future (J. Greenleaf *et al.*, 2009; Smith, 2013b).

As a result of the potential carbon reduction, equity and security benefits, energy efficient retrofit of existing buildings is big business. It is estimated that in the EU there will be around €500 billion of investment in retrofit between 2010-2020 (Eichhammer, Ragwitz and Schlomann, 2013). This investment will come jointly from public and private funds, as a considerable amount of public funding is used via financial incentives to contribute to the cost of retrofit alongside the funds of private recipients (Rohde *et al.*, 2014).

The UK presents a particularly acute case study when considering retrofit. It is estimated that the UK has one of the oldest building stocks in Europe, (the only country in Europe where the majority of buildings were built before 1960) and below average EE ratings (Economidou *et al.*, 2011; ACE, 2015b). While UK buildings are considered to be particularly energy inefficient this does not mean that more energy is currently consumed in UK buildings - more energy is, for example, consumed per unit floor area in German homes (Tuominen *et al.*, 2012). Nonetheless the UK government believe that domestic buildings have highest technical potential for energy savings and carbon abatement of any sector in the economy (DECC, 2016b).

1.2.3. The multiple benefits of energy efficiency

Partly due to the phenomenon of rebounding energy use but also via other intended and unintended consequences EE efforts generally and EE retrofit specifically are recognised as resulting in multiple impacts. Within energy systems transition literature, the perception that EE improvements can help to address the multiple objectives of energy system transitions, has helped to lead to a reframing of the topic in recent years. Reporting from various intergovernmental and non-governmental organisations have sought to connect EE with its perceived ability to address the multiple objectives of a future energy system as well as drawing attention to an additional set of perceived benefits. Reporting on *the multiple benefits of energy efficiency*, implicitly or explicitly, consider EE to be presently undervalued, and argue for a greater recognition of all of its perceived benefits in the decision making of public and private actors.

Recent political efforts to address climate change have been inextricably linked to efforts to improve the efficiency of energy use (Shove, 2017). The largely intangible impacts of climate change mean that actions to mitigate its impacts can be politically difficult (Giddens, 2009). For several years it has been argued that climate change mitigation policy has a set of 'hidden', 'non-energy' or 'co-benefits' (Aunan, Fang, Vennemo, Oye and Seip, 2004; Younger, Morrow-Almeida, *et al.*, 2008; NEAA, 2009) with awareness of these impacts seen as a means of making climate policy more politically and socially acceptable (Aunan, Fang, Vennemo, Oye and Seip, 2004; Smith, 2013b).

Due to the likelihood of improvements in EE resulting in multiple impacts from rebounding energy usage, the EE efforts that are intrinsic to much of early climate mitigation policy lend themselves particularly well to the framing of co-benefits, taking place alongside the primary intended consequence of emission reduction. The rebounding of energy use is such a fundamental part of EE improvements that the idea that EE has a primary consequence –

energy savings and thus carbon emission reductions – who's achievement is *complimented* by a set secondary consequences – co-benefits - has evolved into a multiple benefit framing where there is less emphasis on there being primary and secondary, or a hierarchy of benefits, and instead all perceived benefits are recognised simultaneously.

Acknowledgement of the multiple rebounding impacts from EE and acceptance that energy savings may be lower than predicted has been perceived to have been used to moderate the value of EE (IEA, 2014a). This acknowledgement has, however, in recent years developed into a reframing of EE as synonymous with *multiple benefits*, rather than something which is carried out to just save energy. Multiple benefits is used to avoid "pre-emptive prioritisation of various benefits", with benefits used rather than impacts due to the perception that the impacts are more positive than negative (Fawcett and Killip, 2017).

1.2.4. The multiple benefits of energy efficient retrofit

The multiple benefits of retrofit will almost by their very nature affect multiple stakeholders. This thesis is concerned with how the perceived multiple benefits are perceived to affect two key stakeholders that have, in theory, a rationale to invest in retrofit – the government and households. As highlighted, much retrofit has historically involved a joint contribution to its costs from public and private funds. Whilst there is a *joint* public and private contribution to the costs of retrofit, there is also perceived to be a joint receipt of benefits at the public (government) and private (household) levels. This research disaggregates the perceived benefits into those that apply at the public level, and those that apply private level. For the purposes of this research the following definitions are used:

- Macro level, public benefits: perceived benefits of retrofit that apply beyond the household to which the retrofit is implemented. All public benefits have the potential to benefit all private households, but like a public good they are non-excludable.

- Micro level, private benefits: perceived benefits of retrofit that apply only to the household to which the retrofit is implemented; they are excludable as they are primarily relevant to this household.

This separation of benefits is problematical, with all public benefits potentially relating to private households, and all private household benefits in sum, combining to achieve the macro level, public benefits. Despite the observed overlap, the overall rationale for retrofit is ultimately distinct at the different levels. The separation allows the comparison of the motivations and decision making of the two different levels, and thus a novel, multidisciplinary analysis of the rationales of the joint investors in one of the potentially critical options within energy system transition.

The subject of what the specific benefits of energy efficient retrofit constitute, whether they are considered as conventional or as co-benefits is highly contingent; contingent on the actor to which they apply, their socio, cultural and political environment and also on the period of time in question. The following section focuses on some of the subsets of the most commonly identified benefits for the macro and micro levels, considering some of the sources of related evidence and the reporting that attempts to attract attention to the multiple benefits of EE retrofit.

1.2.4.1. The government – the macro level, public case for energy efficiency retrofit

By framing EE as the ‘hidden’ and then the ‘first fuel’ the IEA has been intrinsically involved with the promotion of government policy on EE in recent years (IEA, 2013). In the ‘Capturing the Multiple Benefits of Energy Efficiency’ report they argue that, of the benefits that can result from EE, to date, only reductions in energy and carbon savings are properly valued within policy, by virtue of them being measured systematically (IEA, 2014a). In their ‘benefit flower’ 13 additional benefits are listed alongside these two ‘conventional’ benefits.

There are various other organisations that have associated EE retrofit with multiple benefits in reporting at least partly directed at government. Reporting of EE's benefits can sometimes present fresh evidence (Copenhagen Economics, 2012; Washan, Stenning and Goodman, 2014; SEAI, 2015; Alexandri *et al.*, 2016), and at other times synthesise existing evidence to present the case (Lazar and Colburn, 2013; IEA, 2014a; ACEEE, 2015; Cluett and Amann, 2015; Puig and Farrell, 2015). Reports like these sit alongside a plethora of news stories and web articles, with the analyses ultimately arguing for a "multiple benefits approach to EE policy"(IEA, 2014a). Such an approach would expand the perspective of policy makers beyond the existing rationale for policy, to include an appreciation of the perceived additional benefits and thus potentially alter the associated level of policy support. Many of these reports do not discern between what benefits may be recognised currently and what might not. Those that do, tend to highlight 'energy savings' as currently recognised while not revealing detail on the specific consequences of energy savings - carbon savings, energy security – this might entail (Copenhagen Economics, 2012; IEA, 2014a; Washan, Stenning and Goodman, 2014). Generally, the consequences of rebound (as opposed to energy saving) are incorporated in the *additional* benefit category.

As mentioned, the IEA consider energy efficiency policies to already be aligned with carbon reduction goals in many countries, and that lowering carbon can be seen with energy demand reduction as a "traditional" benefit of policy (IEA, 2014a). At trans-national governance levels there is much evidence of an established connection between carbon reduction goals and retrofit policy (UNEP, 2009; EU, 2012; IPCC, 2014).

The EE of buildings is connected to health benefits, largely through the health implications of living in an insufficiently warm home. Both physical and mental health implications are considered relevant, and are mainly associated with vulnerable individuals - the elderly, the young and those with pre-existing medical conditions. Excess Winter Deaths and respiratory problems are two of the most commonly identified issues. See Thomson et al (2009) for a systematic review of the evidence, Camprubí et al (2016) for a realist review and Marmot et al (2011) for a review of the health impacts specifically from cold homes. Although the *benefits* are normally the focus when considering retrofit's impact on health there is research that considers the potential negative health impacts from homes overheating, possibly as a result of energy efficient retrofit (Beizaee, Lomas and Firth, 2013; Santamouris and Kolokotsa, 2015).

The health implications of occupants living in retrofitted properties can be valued by governments in terms of the effect it has on the achievement of social policy goals – emission reduction, fuel poverty alleviation etc. There is also a case for large scale retrofit implementation to be valued in terms of its impact on public budgets – an economic rather than a social rationale. Health benefits in this sense are linked to how much public expenditure goes toward health spending. Most countries public budgets contribute to health spending to some degree, but some more than others, for example, the predominantly publically funded health care system in the UK, compared to the mainly private health care system in the USA (WHO, 2016). Age UK (2012) provide an estimate of the cost to the UK National Health Service (NHS) of excessively cold homes - and Cambridge Econometrics estimate the public return on investment from the health impacts of improving the EE of UK homes (Washan, Stenning and Goodman, 2014).

The public economic case for retrofit is further made by its impact on overall employment levels. The impact on employment from retrofit can be assessed in an absolute sense, as employment *supported* by retrofit activity, or in a net sense, as additional employment *created*. It can include direct jobs, and/or indirect jobs associated with additional production and services. The economic impacts of these potential changes in employment profiles can affect public budgets via tax revenues and welfare spending. For analysis on the possible impacts on employment from retrofit see Janssen and Staniaszek (2012) and Saheb et al. (2015) for estimates of jobs at the EU level and UKERC (2014) for a systematic review of the global evidence.

The provision of a reliable and secure energy system is affected by multiple factors – the cost of energy, the availability of sources of energy, and the structures of implementation and maintenance of the system of energy provision. It is argued that energy demand reduction has positive effects on all causes of energy insecurity with the possible exception of energy capacity investment (J. Greenleaf *et al.*, 2009). Effects include reducing reliance on foreign sources of energy (Holmes, Bergamaschi and Mabey, 2014), enabling greater system flexibility and reliability (IPPR, 2007) and lessening the requirement for generation infrastructure(ADE, 2014). The impact retrofit has on energy security is ultimately connected to how much it actually reduces energy demand - this is the same for the carbon but not necessarily for the health or employment benefits. Some benefits, therefore, are linked to associated levels of energy demand reduction – carbon reduction, energy security - whilst other benefits result from the direct and indirect rebounds – health benefits.

The case for governments to either invest central public funds or to create regulatory frameworks that provide funding for retrofit is complicated by issues of value capture and the fact that the perceived multiple benefits of EE retrofit are often relevant to multiple different government departments. Additionally, it has been suggested that there is a temporal dimension to the macro valuation of retrofit benefits, with reporting from Washan et al (Washan, Stenning and Goodman, 2014) finding that due to a lag between investment and return, the public funding of retrofit is likely to occur in one parliamentary term and the multiple possible returns on investment – from health budget savings, fiscal receipts and macroeconomic improvements – in a different term.

The misalignment between the party that covers the costs and that which reaps the benefits – whether it is different government departments or different political administrations – is an example of the ‘free-riding’ that is a common problem for climate change mitigation efforts, where beneficial collective outcomes depend on the actions of single actors (Giddens, 2009). These issues have led to what could be considered an additional reframing of retrofit, namely EE as a ‘national infrastructure priority’ (Frontier Economics, 2015; Amon and Holmes, 2016).

The framing of particular actions as having multiple public benefits is not something that is unique to retrofit or EE more generally. A similar multiple benefit framing is applied to other policy domains in the energy sector. Renewable or clean energy (Brown *et al.*, 2011; Ferroukhi *et al.*, 2016) and climate change in general (Hamilton, Brahmbhatt and Liu, 2017) have received the multiple benefit treatment. Issues framed in a similar manner include cycling – advocated in terms of health, environmental and reduced congestion benefits (Fionia Raje and Saffrey, 2016) – and domestic unconventional gas extraction – which is associated with local job creation, energy security and increased tax revenue (in a set of benefits ultimately very similar to retrofit) (EAC, 2014). Such multi-faceted, heterogeneous evidence production can arguably be connected to the “steering of research priorities” and the “commercialisation of research” associated with the ‘New Production of Knowledge’ (Mode-2) (Nowotny, Scott and Gibbons, 2003).

1.2.4.2. The household – the micro level, private case for energy efficiency retrofit

The following section considers the multiple benefits case that is made at the micro level and how it is distinct from that at the macro level.

Research related to the household case for retrofit tends to focus on a broader set of *multiple influences* – often using the language of drivers and barriers – as opposed to just its benefits (drivers). Much of this research is concerned with trying to assess household’s subjective perception of these influences rather than (like in the macro case) trying to objectively determine the existence or level of the impacts.

Research that does involve measurement of the level of benefits normally focuses on the more quantifiable impacts of retrofit, most commonly that of energy savings. Energy savings per se are not of value to households, but the simultaneous reduction in household energy bills are. This research often simultaneously measures energy savings with rebound effects and thus the rebound literature highlighted earlier is of relevance (se section 1.2.2.). Inverting their rebound findings, Chitnis and Sorrell (Chitnis and Sorrell, 2015) estimate that roughly 50-60% of theoretical energy savings will be achieved from efficiency improvements to UK household gas and electricity. This academic evidence base of energy savings is not directed at households specifically or at any particular stakeholder. The findings of this research will, however, be used to produce information on the benefits of retrofit to households via agencies such as the Energy Savings Trust in the UK (EST, 2017).

Similar to the macro level, the benefits of retrofit at the micro level have at times been framed in terms of primary and co-benefits. Jakob et al, for example, quantify the “co-benefits” of heightened comfort, improved indoor air quality and better protection against external noise and suggest that these could be as valuable as the conventional benefits of energy bill savings (Martin Jakob, 2006).

As highlighted, typically micro level research will assess household attitudes toward a perceived set of benefits or motivations, rather than attempt measurement of the benefits. In an analysis of the relationships between household demographics and their motivations for home EE in the UK, Pelenur and Cruickshank (2014) identify 7 motivations for retrofit – “saving money, environmental, resource efficiency, warmth and comfort, aesthetics and space, health and safety, and time and convenience”. In a review of the literature on household decision making for “energy-relevant investment”, Kastner and Stern (Kastner and

Stern, 2015) observe that the majority of empirical behavioural research has thus far focused on energy "curtailment" rather than investment (retrofit-type) decisions. They cite the most important "positive consequences" of energy-relevant investment to be independence of energy supply, improved thermal comfort, environmental and financial consequences, while they find aesthetic and social consequences to be less important.

A common topic of the academic literature on household motivations for retrofit is the extent to which the economic impacts of retrofit should be emphasised relative to the other non-economic impacts. It is common for research looking at household motivations to conclude that the costs and potential economic returns from retrofit are of paramount importance to households (Gilchrist and Craig, 2014; Aravena, Riquelme and Denny, 2016; CFU, 2017). Such perceptions led to a change in policy design with respect to Energy Performance Certificates (EPC) in the UK (Behavioural Insights Team, 2011). Research from Klöckner and Nayum (2016) in Norway conclude that comfort and health benefits are more important than economic benefits, suggesting that there is not necessarily international consistency with regard to household perception of benefits. It is suggested by some authors that the economic aspects receive too much focus and that the alternative motivating factors and deterrents should receive greater attention when trying to understand why, or persuade households to, retrofit (Christensen *et al.*, 2014; Pettifor, Wilson and Chryssochoidis, 2015; Gillich, Sunikka-Blank and Ford, 2017b).

A developing area of research on the benefits of retrofit is that of its impact on property retail and rental value. This research is most commonly carried out with a properties EPC rating used as the common metric of efficiency. In the earlier stages of EPC implementation some research found there to be a minimal impact on purchase and/or rental price negotiation and decision making (Fuerst and McAllister, 2011; Watts, Jentsch and James, 2011). More recent research suggests that those interested in property purchase or rental are beginning to better appreciate the findings of EPCs, and that this is being recognised in sale and rental prices (Popescu *et al.*, 2012; Hyland, Lyons and Lyons, 2013; Fuerst *et al.*, 2015). There is some evidence from the UK that property values are affected by EE improvements (Fuerst *et al.*, 2015).

The literature on the household retrofit decision making process has considerably greater depth than the literature on government policy decision making on retrofit, with households apparently considered a more legitimate target for influence than governments. The absence of research considering the government 'barriers' to implementing retrofit policy may exist due to a perceived lack of potential for influencing government barriers. While conversely there is a perception that the barriers to household action can be addressed (most commonly by government). While household's perception of the benefits of retrofit has various similarities to the government perception, environmental and energy security are for example, documented benefits at both levels, the overall case for retrofit at the household level is distinctive from that of government.

1.2.5. Collaborative retrofit – government policy and household behaviour

An important characteristic of the home retrofit that has taken place in many different national contexts in recent years, is that it has involved a collaborative investment between public funds and the funds of the private recipients. The following sections consider some of the theory related to the rationale for public policy and to the process of policy formation, as well as the different forms of retrofit policy and theories of household decision making on retrofit.

1.2.5.1. Theoretical rationale for government policy

Despite the perceived multiple public benefits of retrofit, public funds are limited and there are many other issues trying to attract their allocation. How governments raise funds and how they spend them is a universally contentious matter, with the levels of goods and services that are provided publically and the level that is provided privately also a matter of regular debate (Rosen, 2002).

Study of the policy process is commonly thought to have grown in popularity in the post war-period. At this time policy formation was thought of in a linear and relatively rational manner - policy issues are identified, and then they are dealt with, in order to maximise utility and achieve a more efficient allocation of resources (Cairney, 2012f). The process was thought to be largely incremental with a minimal scope for change at any one time (Lindblom, 1979). To understand the rationale for public policy and public funding of retrofit, the identification of ‘public benefits’ from retrofit should be understood with reference to the more conventional identification of the classic political-economic concept of ‘public goods’.

The principle of public goods is that there are goods or services that should be provided by government, as they’re largely non-excludable – it is prohibitively difficult to exclude people from consuming them - and non-rival – the consumption by one actor does not diminish the ability of another to consume them - nature means that despite being of benefit to many, they are unlikely to be provided privately (Chang, 2014). Common examples include a system of national military defence and road networks. According to the IPCC “the climate change problem is inherently a public goods problem” (Toth *et al.*, 2001). By helping to mitigate against the worst impacts of climate change, retrofit can be interpreted as assisting with the provision of a public good. Other sources argue that it is only climate change mitigation and not adaptation that can be viewed as a public good, as the value of adaptation measures can be captured privately (they are excludable) (Hasson, Löfgren and Visser, 2010).

In a concept closely related to public goods, climate change has been considered as “the biggest *market failure* the world has seen” (Stern, 2008), primarily on account of the *externalised* costs of climate change not being included in the cost of the energy sources from which they come. The difference between the perceived ‘techno-economic’ optimum of energy use and that which occurs in practice – the idea that there is an ‘energy efficiency gap’ - is also considered to be partly caused by ‘market failures’ (Jaffe and Stavins, 1994; Brown, 2001). Market failure is generally considered to occur when overall public utility could be increased if goods and services were used more efficiently. In a classic model, however, market failure would only exist if one person could be made better off without anyone being made worse off i.e. Pareto efficiency improvement (Rosen, 2002).

Some authors explain market failure via the language of market barriers, which in this research would apply to the micro level – potential retrofitting households. The perceived barriers of information asymmetry, time inconsistent preferences, the potential disruption caused by implementation and financial constraints such as an absence of capital, provide some means of explaining the existence of a gap between actual and optimal energy efficient retrofit (Howarth and Anderson, 1993; Brophy *et al.*, 1999; Brown, 2001; Steiss and Dunkelberg, 2012; Crandall-Hollick and Sherlock, 2016). Even when there is thought to be a technical absence of market failure, “capital market failure” is thought to occur where the market does not “allocate capital such that it is used most productively from a social point of view” (Kempa and Moslener, 2017).

The identification of market failure (and thus market barriers) is highly subjective and is also normally framed as being necessary for government intervention but not sufficient (Wolf, 1979; Weimer and Vining, 1992; Brown, 2001). Chang points out that not only are there different schools of economic thought as to what is and what isn’t a market failure (Chang, 2014), but that depending on the political, psychological and technological assumptions employed, the logic of market failure can be used to “justify anything from minimal state to full-blown socialist planning” (Chang, 2001). Due to the technical ubiquity of market failures, the theoretical approach of explaining government intervention through the lens of market failures is inherently flawed (Zerbe and Mccurdy, 1999; Carden and Horwitz, 2013).

Market failure theory may not be viewed by all as the proper framework for understanding government intervention but it is still regularly cited by the UK government in the impact assessments (IA) associated with retrofit policy (DECC, 2010, 2012b, 2014a). Policy IAs are a ‘rational-instrumental’ attempt at summing up the costs and benefits involved with a policy intervention in an attempt to determine whether public utility could be increased, and government policy intervention can be justified. The utilisation of formal policy assessment has been a popular tool of recent UK political administrations and are intrinsically associated with the era of New Public Management (NPM) (Hallsworth, Parker and Rutter, 2011; Rutter, 2012). Some authors are sceptical about the ability of IAs to influence the policy process (Pawson, 2006; Hertin *et al.*, 2009), while others look to better understand the role of IAs (and knowledge in general), within the policy process (Radaelli, 1995). The UK is seen as a front-runner in the use of policy IAs in Europe (Radaellii, 2009).

The often quantitative evidence used to produce a retrofit IA (the costs and benefits) needs to be understood in the context of the energy sector – a typical example of an open social system for critical realists. Policy making in the energy sector is considered particularly complex due to the macroeconomic scale of the sector, and the resultant difficulty of gathering meaningful counterfactual evidence, as well as its often highly politicised nature (Sorrell, 2006). The framing of retrofit as having multiple benefits further complicates the process of IA. The value of an “extra-governmental venue” (Schweber *et al.*, 2015) or an “outside view” (Flyvbjerg, 2006) that utilises a range of stakeholders and evidence bases, is regularly highlighted in literature that considers the value of policy IAs.

The concepts of market failure and market barriers are arguably only relevant to *economic policy,* and should not be applied to all government policy interventions. Concerns around equitable distribution also help to justify retrofit policy support. As Kleiman and Teles (2006) observe that “family failures and other social issues gain nothing from being perceived as market failures". While Majone (1994) identifies *social policy* as distinct from policy which emanates from the identification of market failures or *economic policy.* Government intervention therefore, can be divided into economic policy - which attempts to effect the *relative size* of costs and benefits - and social policy - which can be seen as policy effecting *who receives benefits and who pays costs* (Wolf, 1979). Some authors disaggregate social policy between that which is clearly *'redistributive'* i.e. addressing particular priority social groups, and that which is merely *'distributive'* i.e. addressing an economic activity where the trade-off between who pays and who benefits is much less apparent (Lowi, 1972).

Energy efficient retrofit policy can be seen as addressing the provision of public goods, correcting market failures and closing the energy efficiency gap, whilst also affecting issues of social policy and equitable distribution. Amongst policy experts there is agreement that many opportunities for retrofit (and EE in general) that are deemed socially and economically beneficial will not be implemented without some form of government policy intervention (Mallaburn and Eyre, 2013).

1.2.5.2. Theories of the policy process

Researchers (particularly those in the business of interdisciplinarity) should be aware of several different theoretical perspectives and be able to develop multiple competing hypotheses (Sabatier and Weible, 2007) – to be inclusive with respect to theoretical perspectives (Bhaskar and Danermark, 2006). The following section sets out some of the most commonly used theories of how policy is formed and public funds potentially allocated.

The policy decision making of governments is classically depicted as a cyclical process of discrete stages (a so-called 'stages heuristic'). The rationale or agenda setting stage of policy formation, is conventionally viewed as a point in the 'policy cycle', when *the reasons for policy* e.g. the existence of market failure, are considered before any policy is designed, implemented and potentially evaluated – see the Green Book, ROAMEF cycle in the UK, as an example (HM Treasury, 2003). It is, however, argued that this linear, discrete conception of a policy cycle is too simple a model of a complex, messy process, and that multiple rotating cycles within cycles, providing constant feedback to each different stage, would be more appropriate (Cairney, 2012f).

When seeking to interpret the 'rationale' for policy it is important to consider theory that relates to the rationality of political institutions. Originating from the field of behavioural economics (Simon, 1955) and perhaps most commonly associated with the decision making of individuals the identification of 'bounded rationality' and its consequences within decision making is "a fundamental part of most political theories of public policy making" (Cairney, 2012c). A rational choice model (emanating from the original political-economic text-book (Smith, 1776)) is a recognisably simplified means of studying real world policy making, with even advocates accepting that it represents no more than the essence of behaviour. Like any individual those involved with making decisions around public policy do not have the capacity to engage with and rationally interpret all of the evidence on a particular topic, and, therefore, settle for satisfactory rather than optimal outcomes (Cairney, 2012c).

The number of political issues that could reach the political agenda is, in theory, limitless. Political attention is, however, scarce and there is limited psychological space for issues on the agenda (Tosun, Biesenbender and Schulze, 2015). The number of potential policy issues far exceeds "the capabilities of decision making institutions to process them" (Cobb, Ross and Ross, 1976). Agenda-setting theory suggests that there are different stages or forms of agenda one should be aware of. Beginning with the broad public agenda, the governmental agenda (decision makers are paying attention to the issue) and then finally the political decision agenda (an active decision is being taken) (J. Kingdon, 1995). What is on the agenda, and what is kept off it are demonstrations of the different forms of political power (Lukes, 2005). There are no objective means of determining which potential issues should be prominent on the political agenda and the ability of decision makers to assess evidence of what is important is limited, and so the problem definition and framing abilities of issue proponents is critical (Baumgartner and Jones, 1991; Cairney, 2012d).

Theories of how policy is formed are many and varied. Here we will consider some commonly used contemporary theories. Punctuated-equilibrium (PE) theory is based on the empirical observations in the USA (and increasingly in other parts of the world) that policy formation endures long periods of relative stability, interspersed with short periods of concentrated activity. It is linked to the bounded ability of policy makers to address issues, with minimal attention paid for protracted periods, followed by, arguably, disproportionate focus occasionally. It is connected to how issues are defined on the 'public agenda' but also parliamentary cycles, with new administrations inevitably wanting to make their mark on different issues (Baumgartner and Jones, 1991; True, Jones and Baumgartner, 1999; Cairney, 2012e). PE has similarities to the Downesian, issue-attention cycle (which has particular relevance to environmental policy) where policy makers go through cyclical levels of heightened interest in policy topics, followed by the issue receding from view, when the costs and difficulty of dealing with it become too great (Downes, 1972). The movement of an issue to a prominent place on the political agenda or the 'punctuating of the equilibrium' can be precipitated by an imbalance between competing political factions or the definition of a new policy 'image'.

Another common theory that is used to try and explain the policy process and one that has a certain synergy with the study of multiple influences on policy is that of the Advocacy Coalition Framework (ACF). Developed by Sabatier and Jenkins-Smith (1999) the ACF tries to get to grips with the myriad different stakeholders that can be involved with the policy process. In keeping with a perception of multiple benefits the advocates of retrofit do indeed come from far and wide (see section 1.4.1.). Advocacy coalitions are thought to involve actors from a variety of positions held together by a shared belief system, “who show a non-trivial degree of co-ordinated activity over time” (Sabatier, 1988). Some of the visible manifestations of coalitions in the area of retrofit policy include the Association for the Conservation of Energy (ACE, 2013, 2014b) and the Existing Homes Alliance (Existing Homes Alliance Scotland, 2016). Coalition groups are thought to be selective in their choice of evidence, with their actual composition also thought to have some influence on the likelihood of policy change (Cairney, 2012a). The ACF is not simply a means of conceptualising advocacy groups but of the whole network of competing advocacy coalitions within the policy subsystem, as well as that wider political system and other external conditions.

The Multiple Streams (MS) theory of the policy process is used to explain how policies are made and while it could be used to describe the entire process of policy-making, it is particularly relevant to the agenda-setting stage (Zahariadis, 1999). It has also been considered particularly useful when it comes to understanding how climate change might gain political saliency (Pralle, 2009; Carter and Jacobs, 2014). The MS model conceptualises three distinct streams within the policy making process - in order for new policy to be developed a policy problem stream, needs to align with a policy solution stream and a political stream. A particular social or economic problem will only be addressed if there is a solution that is politically acceptable and there is sufficient political will to enact it. Such an occurrence will result in the opening of a ‘policy window’ that can be exploited by policy entrepreneurs (J. Kingdon, 1995). The policy windows and what is politically acceptable are sometimes conceptualised as the movement of an ‘Overton window’ of political possibility (Lehman, 2010). The policy entrepreneurs are quite likely connected to particular advocacy coalitions within a policy sub-system.

Important qualities of MS are that the policy process is non-linear, and that that streams are distinct from each other, containing different actors and institutions (although this distinction is sometimes questioned) (Cairney, 2012b). The solution stream can be conceptualised as a ‘soup’ or a ‘pool’ of ideas developed by specialists within the policy domain, which are ready to be actioned when called upon. Some authors (Zahariadis, 1999) make a distinction between ‘consequential’ coupling of streams, where a problem emerges, and a solution is sought, and ‘doctrinal’ coupling, where “solutions chase problems to which they can be attached” via forces such as ideological politicians looking to make their mark (J. W. Kingdon, 1995). This distinction is the essence of MS theory as it sets out that there is not necessarily a linear (consequential) process of problem identification followed by the search for a solution.

The MS model is not unique to the realms of government policy and is based on the ‘garbage can’ model of organisational decision making (Cohen, March and Olson, 1972). It resonates with the famous adage of Karl Marx that “humanity only sets itself problems that it can solve” (Elliott, 2017), or the words of Victor Hugo (borrowed by Kingdon) that “greater than the tread of mighty armies, is an idea whose time has come” (J. Kingdon, 1995).

1.2.5.3. Government retrofit policy and the household

As highlighted, much of the household retrofit that has taken place in recent years has involved a joint investment from government and households. The distribution of public funds to private households and the creation of collaborative investment scenarios involving both public and private funds is commonplace in liberal economic systems of governance. In the different domains of climate and energy policy, public fund distribution can be used in a variety of direct and indirect ways. Governments can directly allocate public funds by, for example, making subsidies available for renewable energy generation, or they can indirectly support particular firms or individuals by lowering tax obligations and thus potentially lowering public fund collection. The following section considers the different approaches to retrofit policy that exist and how they interact with households. Research that seeks to better understand how and why households might invest in retrofit is often carried out with some reference to how government policy can affect this decision. Some of the *market barriers* that households are perceived to encounter and that are used to justify government policy are outlined in this section.

It has been observed that policy efforts in support of retrofit favour market mechanisms and information based systems, over regulations that enforce household behaviour change (Ricardo-AEA, 2015; Gillich, Sunikka-Blank and Ford, 2017b). Such preferences are witnessed in other forms of climate policy where neo-liberal approaches to governance are considered the norm (Klein, 2015; Elliott, 2017).Visscher et al (Visscher *et al.*, 2016) suggest that there is a pattern to the development of residential EE policy. Command and control regulation might be used initially, but there is a desire to move to more economic incentive-based programmes and a more “dominant role of private parties”.

Policy that seeks to accentuate the drivers and reduce the barriers involved with retrofit includes the provision of information on retrofit costs and benefits via energy performance certificates or face-to-face energy audits, in order to address a perceived lack of information on the part of the household. A lack of information, or ‘information asymmetry’, about home EE opportunities or home energy use more generally, is regularly offered as a principle market barrier or reason for a lack of investment in retrofit (McDonnell and Sinnott, 2010; Johnson *et al.*, 2012; Tuominen *et al.*, 2012; Brounen, Kok and Quigley, 2013; Pollo, 2017; Zuhaib *et al.*, 2017). Research that has looked at how households might use this information outlines the routine and cultural embeddedness of energy use behaviour and how ‘expert’ information is unlikely to be received uncritically (Gram-Hanssen *et al.*, 2007). Information based policy mechanisms are perceived at times as merely having a “supportive” role in overall policy packages (Murphy, Meijer and Visscher, 2012).

The market mechanisms used to address the financial barriers to retrofit are many and varied. They can involve the transfer of funds from public to private sources to cover the upfront cost of retrofit, most commonly as grants or tax incentives, but also as subsidised loans or loan guarantees to address issues of access to capital (Curtin, Mcinerney and Gallachóir, 2016; Kempa and Moslener, 2017). Funds can be sourced from central taxation or from hypothecated sources e.g. energy expenditure. Additional to this the retrofit market can be influenced by fiscal policy, via the taxes that are placed on energy and on retrofit goods and services. Any use of public policy that results in a transfer of funds between sections of society will have equity implications (IRENA, 2014).

Research often concludes that economic influences are paramount in retrofit decision making (Gilchrist and Craig, 2014; Aravena, Riquelme and Denny, 2016; CFU, 2017), although others argue that there is too much emphasis on the economics of retrofit in overall policy programmes. In their paper on 'designing an optimal retrofit programme' Gillich et al (Gillich, Sunikka-Blank and Ford, 2017a) state that of the programmes they studied "nearly all that tracked homeowner motivations found that the cost of a retrofit was cited as the top reason for non-participants, and the availability of a rebate or financing was given among the top reasons for those who did participate". They conclude that therefore programmes are "correct to include financial incentives" within their overall policy package.

The perceived limitations of the economic argument, however, are set out in the evidence review of financial incentives from Curtin et al (Curtin, Mcinerney and Gallachóir, 2016). The author's analysis suggests that "citizen investors do not necessarily act in an economically rational manner". The message, that too much emphasis is put on the economic influences on changing behaviour, is one that is regularly encountered in the retrofit decision-making literature (Bundgaard *et al.*, 2013; Rosenow and Eyre, 2013b; Christensen *et al.*, 2014; Pettifor, Wilson and Chryssochoidis, 2015; Visscher *et al.*, 2016).

The third commonly identified thread of retrofit policy that relates directly to households is that of regulation which requires behaviour change (coercion rather than persuasion). Such approaches have proved relatively unpopular, in part due to the liberal governance paradigm that prevails in many of the countries where retrofit is on the political agenda. Regulation requiring households to retrofit are seen in some countries at the point of major refurbishment. In Germany the ‘Energy Saving Regulations’ (EnEV), mandate strict thermal standards which homeowners have to achieve if they renovate any feature of their home (Galvin and Sunikka-Blank, 2014). In the UK a similar ‘consequential improvement’ regulation was dubbed a ‘conservatory tax’ and was abandoned by government, possibly as it was considered a “potential vote loser” (HOC, 2013; Mallaburn and Eyre, 2013; Guertler and Rosenow, 2016).

Regulations that enforce energy retrofit of existing buildings receive relatively little coverage in the literature, likely because such policy is currently rarely seen aside from in connection to certain refurbishment works (Murphy, Meijer and Visscher, 2012; Camprubí *et al.*, 2016). Mandatory regulations are more common for new appliances and new buildings, resulting in progressive EE improvements, although with regulation compliance not guaranteed (Baiche, Walliman and Ogden, 2006). Policies that address the supply side of retrofit see a mix of incentive and regulation in an often complicated attempt strengthen the supply side in the absence of demand (Killip, 2013).

1.2.5.4. Theories of household retrofit decision-making

There are numerous different theories of behaviour and behaviour change that apply at the micro-level (see Jackson, 2005). In this section we will consider only the theories that have been commonly used in research relating to retrofit behaviour. Although the majority of behavioural research with respect to household energy use has focused on the broader issue of general energy use curtailment (Kastner and Stern, 2015), there is still a considerable amount of research that considers why households might or might not invest in retrofit (in contrast to a scarcity of research on why governments might implement retrofit policy).

Much of this research is carried out with the aim of assisting the development of policy, and will utilise theories of decision-making that inevitably have some overlap with the theories that are used to understand policy decision making. The research at the household level can arguably be characterised as involving a greater level of debate as to how we should conceptualise the process compared with that at the government level, where there is a greater acceptance that multiple theories can have a place. This contention is perhaps due to how the research is applied, with the research at the micro-level of more prescriptive intent.

There is perceived to be a “rationality discourse” (Maller and Horne, 2011) in relation to retrofit behavioural research and subsequent policy development (Wilson and Dowlatabadi, 2007; Wilson, Crane and Chryssochoidis, 2015). RCT is associated with the language of ‘barriers’ to action, with policy interventions framed as an attempt to address the barriers to action e.g. information asymmetry and financial constraints (see section 1.2.5.3.). Research regularly adopts this general framing (Brophy *et al.*, 1999; Brown, 2001; Lowe and Oreszczyn, 2008; Dowson *et al.*, 2012; Pelenur and Cruickshank, 2012) as does government policy justification (DECC, 2012b, 2016b).

The RC perspective is criticised for placing too much emphasis on rationality and has a lack of appreciation for the bounded nature of human agency. The framing is also criticised for perceiving individuals as autonomous agents rather than social ones, and assuming they have an over-riding self-interest (Jackson, 2005). The perceived predominance of RC assumptions in research and policy related to the household level contrasts with the perceived prevalence of bounded rationality assumptions in theories of the policy process (Cairney, 2012c). Whilst there is a self-reported interest in retrofit from households (Wilson, Crane and Chryssochoidis, 2015) it is commonly accepted that we should not expect people’s values to translate into actions (Blake, 1999; Shove, 2010).

Related to RCT is the Theory of Planned Behaviour (TPB) in which individuals are still seen as basing their behaviour on self-interest, but their decisions are seen as being mitigated by three predictors of behaviour. Firstly, their attitudes toward the potential behaviour, related to what the perceived consequences of the action are. Secondly, the social norms that act to influence a person's behaviour. Finally, the perceived behavioural control over the action (the degree of competence that they perceive themselves to have) is also seen as having a major baring on the likelihood to act (Ajzen, 1991).

In a comprehensive synthesis of the behavioural research related to retrofit, Wilson et al (2015) consider RCT and a subsequent "drivers and barriers framing" to be dominant. The authors set out the limitations as they see it of the existing "applied behavioural" research related to retrofit, contrasting this research with the sociological perspective on behaviour. They argue that research should consider households rather than individuals. That retrofit should not be seen as distinct from non-energy home renovations, as those involved with the process will not do so. The socio-technical perspective is raised with the belief that researchers should think of 'homes' rather than just the physical space of a 'house' (for more detail on this principle see (Ellsworth-krebs, Reid and Hunter, 2015)). Finally, it is posited that too often research conceives of discrete renovation events rather than an ongoing process; a principle that is likely to be more salient to the subjects of analysis.

Some research already conceptualises retrofit decision-making in terms of stages rather than as a one-off event (Aravena, Riquelme and Denny, 2016; Klöckner and Nayum, 2016). Klöckner and Nayum (2016) highlight the stages of "not being in a decision mode, deciding what to do, deciding how to do it, and planning implementation". This framing resonates with the 'stage heuristics' of the macro-level policy cycle and the different forms of agendas in policy-making e.g. public, governmental and decision (J. Kingdon, 1995) or simply public and formal agendas (Cobb, Ross and Ross, 1976).

The criticisms of existing approaches to retrofit research emanate from a sociological perspective on behaviour and to a large extent are related to practice theory (PT). PT is associated with various sociological theories of the relationship between human actions and the wider social structure. It is relevant to the structuration theory of Giddens (Giddens, 1984), which sets out to create a model of agency (how we act) and structure (our social and institutional context). The things we do are to a large extent a result of inconspicuous routines and habits (Shove, 2003) that we are locked into and cannot easily choose to break out of. Structuration theory suggests that many human practises e.g. cleaning, socialising etc. should be seen as involving a ‘practical consciousness’ that entails minimal deliberation. In order to motivate retrofitting behaviour, energy consuming practices need to move from a practical to a discursive consciousness (Jackson, 2005). Ultimately, PT is a means of understanding some of the constraints – social norms, ingrained practices – that inhibit the ability of people to act freely (Galvin, 2017).

Social practices are thought to result from co-evolving know-hows, social norms, laws and other institutionalized procedures, and technologies (Bartiaux *et al.*, 2014). The sociological perspective shuns efforts to attribute behavioural change to a list of externalised factors i.e. drivers and barriers (Shove, 2010). The policy recommendations from PT often relate to social contexts. For example, “the importance of knowledge networks in providing advice and help before and during the renovations (Bartiaux *et al.*, 2014) and “community-based domestic retrofit programmes” (Karvonen, 2013). With its emphasis on social structure and social conventions, PT may seem particularly distinct from theories of the policy process, although overlap can be found with the importance of adherence to laws, procedures and norms. Ultimately proponents of a PT model of behaviour believe that problems like climate change should not be framed as “problems of human behaviour” (Shove, 2010).

Practice and structuration theory have some similarities with the ideas of Kahneman and Tversky and behavioural economics (BE) (Tversky and Kahneman, 1979; Kahneman, 2011). These authors identify two systems of thinking where system 1 is fast and intuitive, and system 2 slower and deliberative (Kahneman, 2011). BE research also routinely applies the lens of bounded rationality to decision making, but focuses on the individual rather than the social structure. It can arguably be seen as a middle ground between rational choice, 'homo economicus' perspectives and those of practice theory. It is associated with 'nudge' type policy adaptations (John *et al.*, 2013).

Behavioural economic theory tends to adapt rational choice models to take account of individual's cognitive biases and decision-making anomalies. Frederiks et al (Frederiks, Stenner and Hobman, 2015) set out some of the implications for policy that might arise from an appreciation of BE. For example, experiments reveal that most people weigh losses more heavily than gains and thus financial incentives for retrofit may be more appropriately offered as tax reductions rather than up-front grants. Some of the principles of BE such as optimism bias have gained traction within the decision-making systems of government and organisations (Flyvbjerg, 2006). For example, the UK Green book on the appraisal and evaluation of policy has recently seen the inclusion of supplementary guidance on 'optimism biases' (HM Treasury, 2013). UK

1.2.6. Summary: research background

Retrofit policy is on the political agenda of governments around the world, and is helping to facilitate public and private investment in energy efficient retrofit. The implementation of retrofit is seen by many as an example of appropriate early action in climate change mitigation pathways, due to its potential to frequently offer a return on investment and that many possible retrofit options are established technologies. Energy efficiency also involves rebound effects as technically possible energy savings often result in increased usage of the energy service to which efficiency efforts are applied, and/or increases in the use of other energy services. In part due to the rebounding nature of energy usage, EE in general and EE retrofit specifically have become associated with a broad set of multiple benefits. These multiple benefits apply across the economic and social spectrum and their scattered nature mean there can be a misalignment between investment and value capture. Investment in retrofit, and the perceived multiple benefits of retrofit can apply at both the public, macro level (government) and at the private, micro level (households). This mix of contribution to cost and receipt of benefits means that the implementation of retrofit in existing housing stocks is a particularly complex example of collaborative public and private, macro and micro scale governance.

1.3. Research Design and Methodology

The thesis entails three distinct pieces of empirical research, each of which is documented in the form of an academic journal publication. Each distinct piece has its own specific research questions and/or objectives. The overall thesis is guided by the following research question – why are the relevant actors – government (macro level) and households (micro level) – interested (or not) in engaging in home energy efficiency retrofit activity – what is their rationale for retrofit?

The thesis seeks to develop a fuller understanding of what the rationales for action are, as a means of understanding the potential of home energy retrofit to contribute to a low carbon energy system transition. It seeks to develop a distinctly interdisciplinary perspective on the issue, generating research findings that relate to the policy studies, household behaviour and economics literatures. This interdisciplinary approach is taken as a means of developing a novel and relevant viewpoint on the issue. The following section considers the approach taken and the specific aims and objectives of each distinct piece of research.

1.3.1. Framing the macro-level analysis

As highlighted, there are potentially multiple macro-level, public benefits from retrofit and therefore, potentially multiple different reasons for a government to instigate EE retrofit policy. The macro-level research is not specifically concerned with how retrofit policy emerges but instead on the agenda-setting stage of policy formation and the rationale that is used. The perception of EE as having multiple benefits can in theory lead to different benefits being valued to different extents in different policy contexts. By looking at different national policy contexts where retrofit is known to be on the political agenda, the research seeks to identify both the extent to which a perception of multiple benefits can result in variable rationales for the same policy, and what the implications of this might be. It has been suggested that there is currently limited research on agenda setting in British politics (Carter and Jacobs, 2014).

The literature review found very limited reference to the use of different rationales for the same form of policy. As a result, the macro-level analysis used established theory of the policy process to frame the research. The macro analysis uses the multiple streams model of the policy process to consider the extent to which the perceived multiple benefits of retrofit are recognised within government rationale. The MS model was considered appropriate due to its distinct conceptual separation of policy problems and policy solutions. The 'benefits' of EE policy can be interpreted as reasons for policy, or as problems that can be addressed by policy. Alternative theories of the policy process such as PE and ACF do not make this distinction and thus, although they may be useful framings for analysis of retrofit policy, MS was deemed most appropriate when considering agenda-setting and multiple benefits.

Research questions

1. To what extent are the perceived multiple benefits of energy efficient retrofit recognised within the rationale for policy in 4 different national policy contexts?
2. Does the recognition of multiple benefits in retrofit policy rationale lead to multiplied policy support?
3. Does the overall framing of the policy rationale as social or economic influence the stability and structure of retrofit policy?

The analysis assesses how a selection of perceived benefits are recognised in the policy contexts of the UK, Germany, New Zealand and Ireland. These case studies were chosen due to their comparability in terms of economic background and climate. The benefits of carbon emission reduction, health/fuel poverty benefits, employment/fiscal effects and energy security were chosen after being considered the most prominent categories of benefits in the retrofit literature. This analysis is not concerned with whether the perceived benefits of retrofit are real or not, but with the extent to which they form part of the rationale for policy.

The full set of reasons for government implementing policy may not necessarily be overt, and can be difficult to fully ascertain. This analysis is primarily concerned with capturing a 'big picture' perspective on both the overt, given reasons for retrofit policy, and those that may be less obvious. The benefits of government policy may or may not receive overt recognition from government and become a reason for the policy implementation within the policy rationale stage. Individual governments will often have a distinctive mix of benefits that are recognised, and are thus used as reasons for retrofit policy.

1.3.1.1. Data collection

Evidence of the rationale for policy involved sourcing the policy IAs from each country and establishing the quantified and non-quantified benefits of retrofit policy set out within. This stage was followed by the collection of related government and non-government literature that described the ex-ante design and ex-post operation of the policy. These sources are used to establish a base impression of the overall rationale. They are followed by the 3-4 semi-structured interviews with purposively selected policy experts in each of the case studies. These interviews all took place via the telephone, were recorded and then analysed afterward but not transcribed. The research methodology received ethical approval from the University of Leeds Ethics Committee (Ethics reference: LTSEE-038).

1.3.2. Framing the micro level research

There is a large established literature that considers household decision-making with respect to retrofit. As highlighted, it can be problematic to distinguish between benefits that apply at the macro, public level and those that apply at the micro, private recipient level. Many of the multiple perceived benefits of retrofit apply directly to both public funders and the private recipient. Despite the overlap, there are distinctive cases for retrofit at the macro and micro levels as outlined in research background section.

There are some key differences between the research base at the micro-level and that of the macro-level. Some of these differences are used in the framing of the micro-level research. Firstly, in line with the observations of Wilson et al (Wilson, Crane and Chryssochoidis, 2015) the micro-level research considers general home renovations rather than just retrofit. It is observed that most households do not distinguish between retrofit and general home renovation, and research which does, decontextualises the activity from the point of view of the household. Secondly, the literature at the micro level tends to consider the benefits of retrofit alongside the multiple other influences on household decision-making. As a result, the micro-level research will develop a broader perspective on the household rationale for retrofit incorporating the multiple influences on the household decision-making. The research is based on multiple calls in the background literature for a more heterogeneous perspective of households (Curtin, 2014; Gram-Hanssen, 2014b; Visscher *et al.*, 2016). The research will also endeavour to capture the perspective of the entire household as opposed to single individuals, as this is considered critical to the potential of retrofit implementation (Wilson, Crane and Chryssochoidis, 2015).

In order to develop a heterogeneous understanding of household decision-making and to incorporate multiple influences, the research uses Q-methodology. Q-methodology is a form of abductive reasoning. It is similar to inductive reasoning as it does not begin with a formal theory that is trying to be proved. It differs from induction in that, rather than recorded occurrences being used to predict future occurrences (as with induction), *a best explanation* is sought for the recorded occurrences. Abductive reasoning is used to explain why the pattern of some Q-sorts are correlated with others, with the resultant explanation producing a narrative for the shared experiences (Watts and Stenner, 2012). Abduction and the development of best explanations is one of the principle modes of logical inference within the critical realist approach to social science (Danermark, 2001).

Research questions

1. What narratives exist for the household experience of renovation/retrofit?
2. What do household narrative tell us about the household rationale for retrofit and what are the policy implications of the developed narratives?
3. How can they further the understanding of the relationship, differences and complementarities between general, non-energy home renovations and energy efficiency retrofit?

1.3.2.1. Data collection

The analysis uses Q-methodology and considers a purposive selection of renovators. A concourse of statements for the analysis was gathered from 40 semi-structured interviews. The final data was collected from 24 Q-sort interviews. The research methodology received ethical approval from the University of Leeds Ethics Committee (Ethics reference: LTSEE-036).

1.3.3. Framing the macro and micro comparative analysis

While there is a shared receipt of benefits from retrofit, there has historically also been a joint contribution to its costs, from households and government (Rohde *et al.*, 2014). Both the government and households face the potential of an economic return on investment case for retrofit.

While some authors highlight the importance of both the economic costs and the economic returns from retrofit others suggest that there is too much emphasis on the economics of retrofit (see section 1.2.5.3.). The economics of retrofit are, however, indisputably part of the overall rationale for retrofit. The economic cost and benefit case for retrofit is one that is routinely made within UK government IAs. At the EU level EE programmes are required to be implemented on a strictly cost-effective basis (EC, 2010)., and as a result the most economically viable retrofit has been prioritised, thus progressively diminishing the economics of future retrofit opportunities (Galvin, 2010). The relative contribution to costs and receipt of economic benefits from the public and from the private purses are, therefore, likely to become of increasing relevance.

This research does not take a normative position as to whether the economics of retrofit should be emphasised or not. It does, however, accept that the economics of retrofit comprise an important part of the overall debate around the case for retrofit. As suggested by Lutzenhiser economic analysis strongly influences thinking in energy policy (Lutzenhiser, 2014). While quantitative cost-benefit analysis methods are sometimes considered to be an inappropriate form of analysis (Ackerman, 2008; Pawson, 2013a) other authors feel that they provide an appropriate counter to the multitude of cognitive biases (Sunstein, 2000).

Research questions

1. What is the relative balance of economic costs and benefits between the public (government) and private (households) funders of retrofit?
2. What implications might the relative balance of costs and benefits have for the future of retrofit funding in the UK?

1.3.3.1. Data collection

The analysis in the comparative paper considers the relative investment cases for retrofit of private and public spending. Using the latest data on the costs of retrofit and the value of returns from retrofit - to government and to private households - the analysis presents a scenario for retrofit implementation in the local authority of Kirklees in the North of England. The single implementation scenario is imagined with six different scenarios for contributions to costs - from full public funding to almost exclusively private funding. The different sources of financial return to the public and the private purse are estimated, and the resultant cost-effectiveness case for the public and private are compared in the six different contribution to cost scenarios.

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2. The rationale for energy efficiency policy: assessing the recognition of the multiple benefits of energy efficiency retrofit policy

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Abstract

The rationale for energy efficiency policy can be framed in terms of a variety of different benefits. This paper considers how different benefits have been used within the overall rationale for energy efficient retrofit policy in different contexts. We posit that different

rationales may be used for the same policy response, and that the form of rationale used may affect the design, delivery or the level of policy support, with different rationales making it easier to account for different results. Considering retrofit policy in the contexts of the UK, Germany, New Zealand and Ireland, we characterise policy rationale in each case, assessing what the key perceived benefits have been, and whether they have changed over time. The analysis identifies some marked differences between cases with the recognition of benefits and the ensuing policy rationale resulting from a complex mix of political, social and economic influences. We find that recognition of multiple benefits may not equate with multiplied policy support, and instead it is more likely that different rationales will have relevance at different times, for different audiences. The findings highlight that, alongside evidence for policy, it is important to also consider how the overall rationale for policy is eventually framed.

2.1. Introduction

The more efficient use of energy is a policy concern in a variety of countries, for a variety of reasons. The International Energy Agency (IEA) has in recent years tried to highlight the importance of energy efficiency (EE) to its member states and to give it more priority has reframed it from being a 'hidden fuel' to being the 'first fuel' (IEA, 2014b). This focus is in part due to the perception that demand-side energy policy options have been overlooked in favour of supply-side options (Verbruggen, 2003; Lazar and Colburn, 2013) with a resultant bias toward investment in energy generation over energy demand reduction (IEA, 2015). The IEA estimate that with existing levels of policy support, two thirds of economically viable energy efficiency potential will remain un-tapped by 2035 (IEA, 2014a). The perceived lack of support for energy efficiency is attributed to a variety of its inherent features, including, the nature of its measurement i.e. measuring a negative value (energy savings), the resultant level of return on investment being considered very uncertain, and to the potential for various related rebound effects (Keay, 2011; Sorrell, 2015).

The apparent disregard for EE has resulted in reporting, directed at policy-makers, which focuses on its different perceived *benefits*. Reporting sometimes presents fresh evidence of benefits (Copenhagen Economics, 2012; Washan, Stenning and Goodman, 2014), and at other times synthesises existing evidence to present the case for policy support (Lazar and Colburn, 2013; IEA, 2014a). Many argue that there are multiple different benefits, and therefore potentially multiple different reasons for EE to be on the policy agenda, and some advocate a "multiple benefits approach to energy efficiency policy"(IEA, 2014a), highlighting that the perceived benefits are often not recognised equally or consistently in different national contexts. Ultimately this reporting seeks to expand policy makers' perspective beyond the existing rationale for policy, to include a recognition of additional benefits and thus potentially alter the associated policy support.

In light of calls for policy makers to recognise EE's 'multiple benefits', this paper will assess how much a selection of its perceived benefits have been used as the rationale for EE policy. We focus on a prevalent form of EE policy – energy efficiency retrofit of existing domestic buildings - and consider a selection of different national policy contexts. With activity in domestic buildings often responsible for a large proportion of overall national, territorial energy use (IPCC, 2013; IEA, 2014b), and existing building stocks forecast to compose the majority of the future stock for many decades to come in developed countries (Royal Academy of Engineers, 2010; Schröder *et al.*, 2011; IPCC, 2013) energy efficient retrofit has moved onto the policy agenda of a variety of countries in recent years. The paper considers the extent to which the perceived benefits of carbon emission reduction, health/fuel poverty impacts, employment/fiscal effects and energy security have been employed as the rationale for retrofit policy, in the contexts of the UK, Germany, New Zealand and Ireland; 4 countries with similar economic and climatic backgrounds, where retrofit policy has existed for a number of years.

The paper seeks to describe the mix of perceived benefits that have been used in the overall rationale for policy, helping to bring retrofit on to the policy agenda in recent years. We attempt to explain why the perceived multiple benefits of energy efficiency retrofit may yield different rationales for the same policy response, in different national contexts. We also consider how the rationale may change over time and to what extent the multiple reasons for policy help to achieve multiplied policy support. Finally, we consider whether the form of rationale used might influence the scale and substance of the policy implemented.

To achieve this, the paper firstly sets out the theories of agenda-setting that are used to structure the analysis. We then assess the relevant background of each country, looking at its building stock, building energy use practises, existing policies and associated policy targets. We begin the assessment of policy rationale by considering the formal, stated reasons for policy as set out within policy impact assessments and related policy literature. We then expand on the formal rationale by carrying out a set of semi-structured interviews with relevant experts, and by considering other academic and grey literature from each country. The analysis seeks to contribute to the agenda-setting literature by considering how a particular policy response - retrofit - can be associated with potentially multiple policy benefits, and how this framing might influence its place on the political agenda.

2.2. Background

2.2.1. From co-benefits to multiple benefits

The benefits that are perceived to result from a particular policy response are contingent on the social, economic and political environment, the period of time in question and the actors involved. The idea of a policy response having a primary purpose, as well as a less recognised set of additional or 'co-benefits', has been seen in relation to climate change policy for a number of years (Aunan, Fang, Vennemo, Oye and Seip, 2004; Aunan, Fang, Vennemo, Oye and Seipa, 2004; M. Jakob, 2006; Younger, Morrow-almeida, *et al.*, 2008). The concept has a variety of handles including hidden benefits or non-energy benefits (Schweitzer and Tonn, 2002; ISSP, 2011), and its reporting has been cited as a means of improving the political acceptability of climate policy (Smith, 2013a).

The identification of the co-benefits of climate policy has evolved in recent years into the framing of energy efficiency in terms of its 'multiple benefits', where there is not necessarily an emphasis on any particular benefit. The case for recognising the multiple benefits of energy efficiency has been made by multiple organisations (see ACEEE, 2015; ECEEE, 2014; IEA, 2014b; Lazar and Colburn, 2013; Ryan and Campbell, 2012), with some reports focusing specifically on the multiple benefits of retrofit (see Copenhagen Economics, 2012; Washan et al., 2014). A single policy issue being associated with a wide variety of benefits is a framing that is seen in relation to other policy areas, for example, with regard to cycling provision and hydraulic fracking (EAC, 2014; Fiona Raje and Saffrey, 2016).

2.2.2. Policy problems, policy solutions and the political agenda – Streams within a stream

What is considered a policy issue is "not self-evident", it may be contested, subjective and socially constructed (Wolman, 1981), whilst public policy *formulation* is notoriously inscrutable (Wu *et al.*, 2012). "The cast of people trying to influence Government is vast"(Rose, 2005), with actors in the cast coming from within Government – the department facilitating the policy, the department controlling spending, relevant committees etc. – as well as external actors like lobbying NGOs and private companies. Actors may use evidence of the benefits of energy efficiency strategically, in order to aid their potentially pre-defined positions (Bernauer, Caduff and Science, 2004; Hertin *et al.*, 2009). The process of assessing whether the reported benefits of policy form part of the rationale for a policy may be similarly inscrutable and non-self-evident (J. Kingdon, 1995).

In the vernacular of energy efficiency advocacy, different reasons for policy are articulated using the language of 'benefits'. Another way of viewing these 'benefits' is as policy problems to be addressed. Kingdon's (1995) seminal multiple streams framework for agenda-setting sets out that policy problems, policy solutions and political will are 'independent streams' which need to converge and create a 'policy window' in order for a particular issue to reach the political agenda (Sabatier and Weible, 2014). In light of the emergence of the multiple benefit framing of energy efficiency and in line with Kingdon's multiple streams framework, the analysis here considers the potential for multiple, diverse, policy problem streams - multiple benefits - to converge with a single policy solution stream – retrofit - to excite political will and move an issue onto the political agenda.

Using the logic of *agenda-shaping* (Tallberg, 2003), we consider the influence of the different policy problems on both bringing retrofit to the agenda – agenda setting – and on emphasising or de-emphasising retrofit's place on the agenda – agenda structuring – critically considering the policy dynamics (Baumgartner, Green-Pedersen and Jones, 2006). In order to relate to the theoretical framing in this analysis we refer to retrofit policy as a 'policy solution', we do not, however, infer that any of the policies considered have *solved* their associated policy problems.

With the potential for multiple problems being associated with a single policy solution, we also consider whether the principle of 'problem load' - conventionally used to describe the bounded nature of the number of policy problems that can be addressed by policy makers at one time (Sabatier and Weible, 2014) – has relevance to the multiple benefit framing, and whether there is a limit to the number of problems that can be acceptably associated with a single policy solution at one time.

Finally, with there being potentially multiple reasons contributing to a single policy solution's overall rationale, we consider whether the rationale for policy may affect the scale and stability of the policy itself. The perceived benefits of retrofit cover a wide range of policy issues – here we focus on carbon emission reduction, fuel poverty/health, employment/fiscal effects and energy security. In this analysis we will compare rationales in terms of the extent to which they can be considered as economic – influencing the overall size of the costs and benefits and potentially 'adding value' to the economy – or as social – affecting matters of equity or how the costs and benefits are distributed. Although each of the perceived benefits highlighted for analysis here can be advocated in both economic and/or social terms, *the overall rationale and the policy design* may offer insights into the extent to which policy is expected to provide an economic return, or to address matters of social equity. As Radaelli observes with regard to the use of policy assessments "If more than one logic is at work… it becomes easier to account for different results" (Radaelli, 2005).

2.3. Methods

2.3.1. Case study criteria

Retrofit is more commonly a concern in countries were existing domestic buildings are relatively old and are expected to comprise the majority of the stock for many years to come. This analysis will be restricted to countries where retrofit of existing buildings is a higher priority, and which have similar economic backgrounds. In line with the IEA's calls for a greater appreciation of the benefits of energy efficiency in policy decision making, the analysis will focus on IEA member countries, those within the OECD.

Alongside this, we will consider case studies that have a similar climate and therefore requirement for similar forms of retrofit. In the countries of Northern and Central Europe, around two thirds of energy used in a home is used to heat spaces (Economidou *et al.*, 2011), and thus retrofitting the building fabric is more prevalent. Due to the predominance of OECD members in temperate regions such as Northern and Central Europe, case studies will be restricted to those within a temperate climatic region. The final criterion for case studies applies to availability of evidence on policy rationale, with a selection of countries with the best available evidence considered. The analysis will therefore assess the rationale for policy in the UK, Germany, New Zealand and Ireland, with a focus on the period between 2005 and 2014.

2.3.2. Methods for case study comparison

2.3.2.1. Background and policy support

The analysis will begin by outlining some details for each country that are relevant to the comparison. These include the state of their building stock, sources of building energy use, and the main policies and targets associated with retrofit. There are a variety of different methods of retrofit policy support. Financial support requiring funds from central government and/or leveraged funds from the private sector (e.g. Energy Supplier Obligations), may exist alongside non-financial mechanisms such as regulation or information based systems (RAP, 2010). As there are both financial and non-financial policy levers, levels of policy support cannot be judged solely on the amount of funding that is allocated. Levels of funding, however, can give some impression of the level of policy support, particularly in terms of changes over time (Baumgartner, Green-Pedersen and Jones, 2006). In each case study an estimate of the level of historical funding support will be given, as one method (by no means comprehensive) of comparing levels of policy support with the rationale for policy. We will also consider how the case studies compare in terms of non-financial policy.

2.3.2.2. Assessment of policy rationale

This process begins with a review of relevant policy impact assessments (IA). Despite being an attempt at a rational, instrumental approach to policy, IAs can vary significantly between countries (Radaelli, 2005). Whether they are ex-ante (before) or ex-post (after) policy implementations IAs regularly attempt to assess a policy's costs and benefits, either quantitatively or qualitatively. The analysis considers what benefits are included within each national IA; whether benefits are included quantitatively, as part of a cost benefit analysis, qualitatively or not at all. The analysis takes the view of Ackerman that in cost benefit analysis quantified benefits are valued more highly than non-quantified benefits (Ackerman, 2008). There is a long-standing critical literature on the role of these assessments, and whether they constitute 'evidence based policy', or 'policy based evidence'(Bina, 2002; Hertin *et al.*, 2009). Due to the established misgivings, this analysis will consider the IAs to offer only a preliminary view on what the rationale for policy might involve, and to be by no means a comprehensive account of policy rationale.

Following this, additional government literature is examined to assess the policy design, and consider how this relates to the rationale for its existence. By doing this we seek to assess the revealed preferences of the policy, in comparison to the stated preferences of the IAs. For example, one policy may be designed to target the maximum carbon savings, while others may prioritise certain social groups with the benefits from the rebound effect in mind (Font Vivanco, Kemp and van der Voet, 2016).

Finally, the analysis involves a set of expert interviews – actors involved in policy development and evaluation, or academics involved with the evidence process - for each case study (for description of interview process see Annex). Interviews were expected to offer a more insightful view of the overall rationale than that offered in the formal declarations of the IA (detail on the structure of the interviews is given in the Annex). The perceived benefits focused on in this analysis - carbon emission reduction, health/fuel poverty benefits, employment/fiscal effects and energy security – were chosen after being considered the most prominent categories of benefits in the retrofit and multiple benefits literature.

The analysis is not concerned with whether the perceived benefits of retrofit are real or not, but with the extent to which they are considered to be the policy problems associated with the retrofit policy solution. We accept that with regard to the existence and level of policy we are not capable of "exercising control over all the historical and contemporaneous, macro- and micro- conditions, that have influenced the situation we wish to explain" (Pawson, 2006) and that the scope for associating causes and effects in macroeconomics is limited (Lawson, 1997). We instead try to assess the 'big picture' of policy rationale, the extent to which the same policy solution can be associated with multiple policy problems and what the implications of this may be.

Table 1: Policy expert interviews

Case study	Number	Interviewee description	Date of interview
UK	1a	UK University, Energy policy expert	13th January 2016
	1b	UK Government, Economist	14th January 2016
	1c	UK Government, Researcher	22nd January 2016
	1d	Retrofit consultant, UK expert	26th January 2016
Germany	2a	UK University, retrofit policy expert	11th December 2015
	2b	German Energy Research Institute, Energy expert	28th January 2016
	2c	German Energy Research Institute, Energy expert	5th February 2016
New Zealand	3a	NZ University, Buildings/Energy expert	24th November 2015

	3b	NZ University, Buildings/Energy expert	3rd December 2015
	3c	Policy Research Institute, Research Fellow	8th December 2015
	3d	Former Member of NZ Parliament	11th December 2015
Ireland	4a	Irish Energy Institute, Researcher	6th January 2016
	4b	Irish University, Energy Economist	15th January 2016
	4c	UK University, Energy policy expert	19th January 2016
	4d	Irish University, Economist	11th February 2016

2.4. Results

2.4.1. UK

2.4.1.1. Background and policy support

The UK has one of the oldest building stocks in Europe (Economidou *et al.*, 2011), with the stock considered poor in terms of thermal performance by European standards (ACE, 2015b). The vast majority of homes are heated via a gas grid (DECC, 2015), which was largely constructed in the 1970/80s, when the UK was a net exporter of oil and gas. Since 2004 it has been a net importer with the data for 2012 showing that 60% of gas was imported (DECC, 2013a). Electricity generation in recent years has been supplied with roughly 30% contributions from coal and gas, 20% from nuclear and renewables up to 20% in 2014 (DECC, 2014b). Retail energy prices have risen significantly above the rate of inflation since 2005 with a slowdown in the last 2 years (IEA, 2016a). Carbon reduction targets peak at 80% in 2050 (1990 baseline), while targets also exist for 'fuel poverty' - originally to eradicate it by 2010, (DTI, 2001) with a lack of success leading to a less ambitious target for retrofit improvements from 2012 (Hills, 2012).

The main policy encouraging retrofit has been subsidies made from Energy Supplier Obligations (ESO). Low levels of ESO were in place in the UK since the privatisation of the energy sector in the 1990s, with significant increases in 2005 and 2008. In 2012 the Energy Company Obligation (ECO) was joined by a new financing scheme, the Green Deal (GD) (Rosenow and Eyre, 2013a). The level of obligation within ECO was effectively halved in 2013, partly due to concerns it was having an inflationary impact on energy prices – the cost of ESOs is passed onto energy bills (ACE, 2014b) - while the GD was effectively scrapped in 2015 partly due to a lack of uptake (Rosenow and Eyre, 2016). ESOs have normally had around 50% of their spending focused on priority social group's i.e. low income and elderly. Non-financial policy mechanisms include EU mandated Energy Performance Certificates (EPCs), and brief and limited regulation of the private rental sector, while there are no regulated performance standards for retrofit.

2.4.1.2. Assessment of policy rationale

The ex-ante IAs for retrofit policy involve quantifying the benefits to be included in a Cost/Benefit Analysis (CBA), and identifying ‘wider impacts’ which are not quantified. Quantified benefits include energy savings, air quality improvements, comfort benefits and carbon savings benefits, while the wider impacts include potential health benefits (DECC, 2010, 2012b). The IA estimates the number of jobs associated with the policies, with this measurement made for jobs ‘supported’, rather than an estimate of any net change in employment levels (jobs created). Retrofit policy’s positive impact on improving the security of UK energy supply is mentioned several times.

The considerable increases in ESOs seen in 2005 and then 2008 were mainly attributed by literature and interview sources (Rosenow, 2012; Carter and Jacobs, 2014)(interviews 1a, 1b) to concerted efforts to reduce carbon emissions. This effort can partly be seen in the ESO policy’s name change in 2008 to include the word ‘carbon’. The issue of fuel poverty is, however, also seen as a critical driver in the UK at this time, with some interviewees putting it or ‘social concerns’ as a more important motivation than carbon (1d). Another interviewee attributed the increases of 2005 and 2008 predominantly to the carbon driver, but the extension in the scheme from 2010-2012 at the same funding level, to the increases in energy prices around this time, and resultant concerns around the affordability of energy and thus fuel poverty (1a). Further emphasis on fuel poverty (at the expense of carbon), was observed by literature sources (Rosenow, Platt and Flanagan, 2013), and can also be seen in the alteration of the ESO scheme announced in late 2013. The perception that ESO policy acts to increase energy bills was a major factor in the significant reduction in ESO funding, with the cut occurring to the carbon section of the policy, rather than the socially focused, fuel poverty section (ACE, 2014a). The shifting rationale for ESO policy has been linguistically consolidated by the decision to call the scheme the Fuel Poverty Obligation from 2018 (DECC, 2016a).

The rationale for retrofit policy in the UK comes predominantly from carbon reduction and fuel poverty alleviation. The quantified comfort benefit in the IA is recognition that the impacts of retrofit may transpire as a warmer home rather than energy/carbon savings. The specifically health impacts of retrofit, including any reduction in public health spending, are not felt as keenly with health impacts an unquantified wider impact in the IA.

The potential employment impacts of policy are included in the IAs as jobs supported rather than created. The idea of retrofit policy resulting in job creation “needs to be treated with caution” according to a government source (1b), with the scepticism of a single policy having a positive impact on net employment attributed to “treasury orthodoxy” (1a). There was little sentiment from the interviews that the potential employment benefit of retrofit is one which “cuts much ice in the UK” (1a, 1d). Other sources observe the energy efficiency industry increasing their lobbying influence since the expansion of ESOs (Rosenow, 2012), with recent attempts to redefine retrofit as an infrastructure priority (Frontier Economics, 2015; UK Green Building Council, 2013) partly an attempt to highlight the employment benefits of retrofit.

Despite being regularly mentioned in the IAs energy security was considered to have been a neglected influence on retrofit policy by the interviewees, with only one raising the issue as relevant to the rationale for policy (1d).

2.4.2. Germany

2.4.2.1. Background and policy support

The current German building stock has an age profile similar to the EU average. Energy performance of the stock compares favourably with countries of a similar climate (Economidou *et al.*, 2011). Around half of heating demand is met by gas, about a quarter by oil and the rest from renewables and district heat (BMWi, 2015). Electricity, historically, has come from a mix of fossil fuels and nuclear similar to that of the UK, with a broad mix of renewable sources gradually increasing their contribution - around 25% in 2013 (IEA, 2016b). Similarly to the UK, Germany currently has a negative energy trade balance, (roughly 60% of energy is imported) although this balance has existed for much longer than it has in the UK (Schröder *et al.*, 2011). Retail energy prices have increased above the rate of inflation in recent years but not at the level seen in the UK (IEA, 2016a). The term Energiewende, or Energy Transition, refers to the process of phasing out nuclear power and eventually fossil fuel generation from its energy portfolio. Energiewende's origins can be traced back several decades, and it is perceived to have a broad political consensus (Strunz, 2014; Hake *et al.*, 2015), with legislated targets including an 80-95% reduction in carbon emissions, and a 50% reduction in primary energy use by 2050 (Agora Energiewende, 2013).

Retrofit policy support comes predominantly in the form of a low interest soft-loan system, the CO_2 Buildings Rehabilitation Programme (CBRP), with public funds administered by the KfW development bank. The interest rate is partly determined by the level of retrofit that is to be carried out, with lower rates on offer for loans that are used to achieve deeper retrofits. Grants were introduced to the scheme from 2007, but have comprised a low amount of funding in comparison to subsidised loans (Rosenow *et al.*, 2013). Retrofit funding is linked to central government budgets, with funding support increasing markedly after 2005, peaking in 2009 and then stabilising at a more consistent level (Dorendorf, Area and Privatkundenbank, 2013). Retrofit policy in Germany does not have a targeted social focus, with no funding ring-fenced for certain social groups. The loan mechanism allows for significant leveraging of private investment, something which is not typically achieved as much by grant funding. This system means that CBRP is associated with tens of billions of euros more retrofit investment, than the public funding alone (Rosenow and Galvin, 2013). German policy includes regulation - Energy Saving Ordinance - which sets performance requirements for major retrofit projects (Galvin, 2012). While it offers an information based policy system that includes EPCs and is like many other countries in the EU (Ricardo-AEA, 2015).

2.4.2.2. Assessment of policy rationale

The CBRP scheme is subject to an IA each year with the overall energy/carbon savings and the jobs figures calculated. Jobs figures receive significant attention being disaggregated into direct and indirect jobs in the construction, materials and services sectors as well as an urban and rural disaggregation. There is no mention of health or energy security benefits, but there is a consideration of the impact on tax revenues (IWU, 2014). The IAs provide regular feedback on the policy's performance but some interviewees expressed concern about how rigorous they were (2a, 2c).

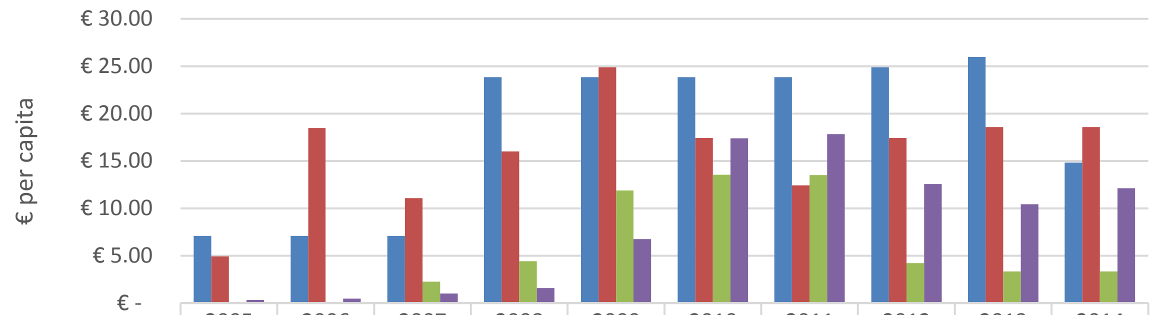
Retrofit policy has existed in Germany over a similar timeframe to that of the UK. Like the UK the word carbon has been included in its title, but unlike the UK, this reference has been a continuous presence from retrofit policy inception to the present day. Loans are given on the basis of achieving a certain level of carbon (not energy) saving (Rosenow, 2013). The emphasis on overall saving level, and no part of the scheme that targets certain social groups, arguably highlights a scheme more carbon focused than the UK equivalent.

It has been suggested that the 'sub-objectives' of German climate policy are economic stimulus and job creation (Kuckshinrichs, Kronenberg and Hansen, 2010; Schröder *et al.*, 2011). KfW commissioned research says that policy funding forms 'part of the government's economic stimulus package and hence also had a political and economic motivation' (Jülich, 2011) In analysis carried out in 2011, Rosenow assessed the politics of the CBRP scheme, and found a majority of interviewees observing that politicians see the policy as having positive economic effects and creating jobs (Rosenow, 2013). The interviewees in *the analysis here* overall were unsure of the influence of employment creation on the policy over the longer term, with some perceiving it as "secondary to carbon reduction" (2c) and some as actually "not that important" (2b).

The potential impacts on health are not mentioned in the policy IA. They are not part of the rationale for policy at all in the view of some interviewees (2a, 2c) but are becoming more important in recent years according to others (2b). This lack of a specific social focus within retrofit policy was partly attributed to the significance of Wohngeld policy, where the heating bills of certain social groups are covered by the state (2c).

Even in Germany "a big energy user, with little internal supply" (Schröder *et al.*, 2011) the issue of energy security was not considered to play much of a role in retrofit policy rationale. All interviewees pointed out that at sporadic points in the past, geo-political tensions have given rise to some concern, but that this concern was fleeting (2a, 2b, 2c).

Figure 1: Public funding per capita for retrofit policy over time



	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014
UK	€ 7.09	€ 7.09	€ 7.09	€ 23.84	€ 23.84	€ 23.84	€ 23.84	€ 24.88	€ 25.97	€ 14.84
Germany	€ 4.93	€ 18.47	€ 11.08	€ 16.01	€ 24.88	€ 17.41	€ 12.44	€ 17.41	€ 18.59	€ 18.59
New Zealand	€ -	€ -	€ 2.26	€ 4.41	€ 11.90	€ 13.54	€ 13.50	€ 4.21	€ 3.33	€ 3.33
Ireland	€ 0.33	€ 0.48	€ 1.02	€ 1.59	€ 6.74	€ 17.39	€ 17.83	€ 12.55	€ 10.43	€ 12.13

Note on Figure 1: the graph was constructed using data from the references outlined above. In some countries, for some years, exact data was not available and assumptions were necessary to achieve estimates of funding.

Note on exchange rates: both UK and NZ funding were converted to Euros, with information provided below on the exchange rates used. As a result of exchange rate fluctuation at this time, converted funding levels in the UK and NZ will see changes in their levels that do not precisely correspond with the changes in the levels of funding in each country that would have occurred in their domestic currency.

UK exchange rate (€/£): 2005-2008 = 1.40; 2008-2011 = 1.15; 2012-2014 = 1.20

NZ exchange rate (€/NZ$): 2005-2008 = 0.52; 2008-2011 = 0.55; 2012-2014 = 0.60

Figure 1 references

UK data refs

(Lees, 2008; IPPR, 2012; ACE, 2015a; CCC, 2015a)

Germany data

(Buchan, 2012; Dorendorf, 2013; Rosenow, 2013; Rosenow *et al.*, 2013)

New Zealand data

(T. Denne, 2011; A. Grimes, T. Denne, P. Howden-Chapman, R. Arnold, L. Telfar-Barnard, N. Preval, 2012)

Ireland data

(SEI, 2005, 2006, 2007, SEAI, 2009, 2010, 2011, 2012, 2013, 2014)

2.4.3. New Zealand

2.4.3.1. Background and policy support

According to various sources, NZ homes are poorly constructed and heated, with 84% of homes estimated to have inadequate insulation in 2005 (Howden-Chapman *et al.*, 2005; Barnard *et al.*, 2011). It is estimated that only 34% of energy in domestic buildings is used for space heating, with 29% for water heating and the rest electricity (Isaacs *et al.*, 2010). This proportion of energy used for space heating is much lower than the other case studies (where around 60% of domestic energy is typically used) (Economidou *et al.*, 2011). This situation has been partly attributed to a lack of central heating and cultural attitudes in NZ (Cupples, Guyatt and Pearce, 2007; Howden-Chapman *et al.*, 2012). Space heat is provided by solid fuels (56%), electricity (24%) and gas (14%) (Grimes *et al.*, 2011). but low amounts of space heating in the domestic energy mix, mean electricity is of greater importance to overall energy use, with the price of electricity increasing much faster than inflation since 2000 (IEA, 2016a). While there is a GHG reduction target of 50% (below 1990) by 2050 (Government of New Zealand, 2011), around 50% of emissions come from agriculture, and around 70% of electricity generation is renewable (MBIE, 2015), meaning that emission reduction targets have less relevance to the housing sector than in some other countries.

The Energywise Home Grants scheme was launched in 2004 with a solely low income focus, and insulated 14,000 homes in 2008/09 (T. Denne, 2011). In 2009 the more ambitious Warm Up NZ was introduced, which had the target of insulating roughly 200,000 homes over its lifetime (A. Grimes, T. Denne, P. Howden-Chapman, R. Arnold, L. Telfar-Barnard, N. Preval, 2012). WUNZ is a grant scheme using central government funds, with roughly half of grants between 2009 – 2013 reserved for low income groups (T. Denne, 2011). The second round of WUNZ, started in 2013, was exclusively reserved for priority social groups. In the period of analysis there were both information campaigns and loans made available to promote retrofit in NZ, but these did not receive much public subsidy. Regulatory measures applied only to appliance efficiency and not the standard of retrofit (Ricardo-AEA, 2015).

2.4.3.2. Assessment of policy rationale

The IA of the WUNZ scheme was carried out ex-post and contains real-world estimates of the policy's impacts. The IA entails three distinct reports; one assessing the energy savings, one the health impacts and one the economic and employment impacts (Barnard *et al.*, 2011; Grimes *et al.*, 2011; T. Denne, 2011). The commissioning of distinct reports for the wider health and the economic impacts, and no specific report on carbon savings would appear to signal a different set of priorities to that of the assessments in the UK and Germany. The results from the assessments reveal energy savings lower than predicted (Grimes *et al.*, no date) , positive net employment and health impacts that make up 99% of overall benefits (A. Grimes, T. Denne, P. Howden-Chapman, R. Arnold, L. Telfar-Barnard, N. Preval, 2012).

Interviews emphasised that there is a strong link in NZ between retrofitting homes and health benefits, with media coverage of the scheme focusing on these rather than economic or environmental arguments (3a, 3c). Health impacts precede energy savings and employment in the list of objectives in the IA (T. Denne, 2011; A. Grimes, T. Denne, P. Howden-Chapman, R. Arnold, L. Telfar-Barnard, N. Preval, 2012), with this focus partly attributed by most interviewees (3a, 3c, 3d) to longstanding research into the health benefits of retrofitting homes (Howden-Chapman *et al.*, 2005, 2007; Chapman *et al.*, 2009).

The political background to the policy involved negotiations from around 2007, between the Green Party and the Labour Party, in which a home insulation policy was forwarded by the Greens and accepted by Labour. A change in government in 2008 resulted in the initial abandonment of the scheme. The policy was eventually funded however, when Green party activism and support from businesses helped convince the new (National Party) Government that the policy could be used as a means of creating employment (in a time of recession) (3a, 3c, 3d).

The connection between carbon reduction and retrofit policy was made in some interviews (3c, 3d) but it is noteworthy that none of the sub-evaluations of the policy mention carbon and it is not until the summary CBA that it is considered (A. Grimes, T. Denne, P. Howden-Chapman, R. Arnold, L. Telfar-Barnard, N. Preval, 2012). This is possibly a result of the scale of renewable energy in NZ, and the relatively small contribution of buildings to total emissions. Some interviews also attributed it to a reluctance to address climate change in some NZ political parties (3b, 3d). No association between energy security and retrofit policy was raised by interviewees or mentioned in any of the literature for NZ. When prompted on the issue, all interviewees said that it was not something that was part of retrofit policy rationale largely due to a large contribution to electricity from renewables and significant indigenous energy resources for heat.

2.4.4. Ireland

2.4.4.1. Background and policy support

Ireland has one of the most carbon intensive building stocks in Europe, producing much more CO_2 per unit area than Germany and the UK. It has, however, a younger stock than Germany and the UK (Economidou *et al.*, 2011). The carbon intensity of the Irish stock can partly be attributed to the widespread use of oil for heat and (despite being relatively new) the poor thermal performance of parts of its building fabric (ACE, 2015b). Proportionally, however, buildings contribution to overall GHG emissions is lower in Ireland than it is in the UK and Germany, largely due to a large, methane producing, agricultural sector (EPA, 2016).

Like other countries of a similar economic and climatic background, space heating comprises the majority of energy used in Irish buildings (Economidou *et al.*, 2011). This heat is estimated to be supplied roughly 45% by gas, 45% by oil, 5% by solid fuel and 5% by electricity (Scheer and Motherway, 2011) Electricity is sourced from predominantly gas power stations, with some contribution from coal/solid fuel power stations, and roughly 20% from renewables (Deane *et al.*, 2013). In line with EU policy Ireland has legally binding carbon emission reduction targets, although the residential sector makes up a relatively small proportion of overall emissions because of a large contribution from agricultural emissions (similar to NZ) (EPA, 2015). Since 2005 energy prices have risen much faster than consumer inflation (IEA, 2016a).

Funding support for retrofit in homes comes in the form of a grant system, funded through general taxation. The scheme originated in 2003 with a small fund focused on low income housing. The overall spend from this programme was expanded significantly in 2009 and again in 2010, with increased funding for the low income scheme and the arrival of a universal fund, immediately larger than the low income fund (SEAI, 2004)(SEAI, 2010). In recent years the low income and universal funds have been at comparable levels. Despite the ring-fencing of funds for low-income groups there are currently no fuel poverty targets in Ireland. Ireland has information based policy to promote retrofit that is broadly comparable to the rest of the EU. There is currently minimal regulation for retrofit standards and no subsidised finance scheme (Ricardo-AEA, 2015).

2.4.4.2. Assessment of policy rationale

An ex-post IA of the Better Energy scheme was carried out by the Sustainable Energy Authority of Ireland (SEAI) in 2011 (Scheer and Motherway, 2011). This assessment quantifies the energy/carbon savings and other pollutant savings, and identifies jobs supported, improved comfort, health benefits as unquantified co-benefits. A fiscal analysis is included which incorporates taxation changes from altered consumption and some account of the fiscal impact of supported employment but does not include any fiscal impacts from health improvements.

Initial retrofit policy in Ireland was specifically for low income homes, it was not until 2008 that a universal fund was created. This initial focus indicates that a fuel poverty rationale preceded any other rationale, a view supported by all interviews. Unlike the UK, however, there is no definition and monitoring of numbers of people in fuel poverty but this may be more attributable to a lack of administrative resource than a lesser recognition (4b).

When questioned on the rationale for retrofit policy in Ireland, however, all interviewees gave a similar initial response - the existence of EU mandated carbon targets. Overall funding for retrofit policy grew rapidly with the arrival of the universal grant scheme in 2008. This substantial increase in budget is remarkable due to policies of austerity being applied to Irish public budgets at this time (Fraser, Murphy and Kelly, 2013). The paradoxical increase is partly attributed in interviews (4c, 4d) to the presence of the Green Party in government and more specifically a Green Party MP as the minister responsible for retrofit policy. With similarities to NZ, this funding increase was attributed in interviews to the relevant Green minister, but also to the jobs benefit coming to the fore in the arguments utilised in a time of recession (4a, 4b, 4d). The connection between jobs and retrofit policy is also regularly seen in official documents from SEAI (SEAI, 2012, 2013, 2014).

The issue of energy security was again secondary to other drivers although it was considered to be at least part of the policy rationale in some interviews (4b, 4c). One interviewee argued that there were energy security concerns but these tended to focus on the provision of electricity and were not particularly associated with retrofit policy (4d).

2.5. Discussion

As mentioned, due to the inscrutable nature of the policy process we have only sought to and are only capable of recognising the 'big picture' with regard to overall rationale for the adoption of domestic retrofit policy and the way that different benefits are recognised. The 'big picture' rationales for our case studies do, however, reveal marked and interesting points of comparison. Three of the four case studies demonstrated a strong connection between retrofit policy and carbon reduction. The countries with the highest levels of funding available (per capita), Germany and the UK, included the word 'carbon' in their figurehead policy for at least a time. It is interesting to note that the one country that demonstrated the least recognition of the carbon benefit, New Zealand, had the lowest per capita spend. The lack of association between retrofit policy and carbon reduction in NZ could be attributed to a relatively low contribution to overall emissions from buildings, and, potentially, a government which does not prioritise climate change.

The carbon benefit is conventionally addressed in certain quantitative terms, involving measurement and targets. It also involves implicit consequences i.e. the impacts of climate change, in a way that other benefits do not. The targets and consequences provide the carbon benefit with an impetus that is perhaps not seen from any of the other policy problems. Fuel poverty in the UK is the only other policy problem which sees systematic targeting and monitoring. Whether other policy benefits could be addressed in a similar way e.g. reporting retrofit's impact on a health metric and whether this would be desirable, is a matter for debate (see Rutter and Knighton, 2012).

Health benefits were clearly the main policy problem associated with retrofit in NZ. This can be attributed to a particularly poor housing stock, the impact of research on the topic of health and cold homes and a rapid real term increase in electricity prices in recent years (Howden-Chapman *et al.*, 2012) – electricity represents 69% of all domestic energy use in NZ

(HEEP and BRANZ, 2006). Rising electricity prices have helped to bring energy affordability, and thus the efficiency of the housing stock, into the political spotlight (Howden-Chapman *et al.*, 2012). Energy prices have risen in real terms in every case study considered, helping to bring energy affordability and fuel poverty onto the agenda in some cases. The prominence of the health benefit rationale in NZ is arguably also attributable to the relative lack of recognition of the carbon policy problem in NZ, with this possibly giving prevalence to an alternative policy problem stream; if the proportional contribution of housing to overall NZ emissions was greater, would the main policy problem associated with retrofit be its potential health benefits?

Despite the link between retrofit and health, the concept of *fuel poverty* does not generate the political concern in NZ that it does in the UK (Howden-Chapman *et al.*, 2012). In the UK, fuel poverty has been a political issue for around two decades, with monitoring and targeting taking place over a similar time scale (ACE, 2002). There was no commitment to reducing or eliminating fuel poverty in NZ, and no official monitoring or evaluation. The identification of fuel poverty as a policy issue is clearly somewhat related to public health concerns(SEI, 2003; Hills, 2012; Howden-Chapman *et al.*, 2012). It's most common definitions, however, which focus on income, mean that associated policy should not be seen simply as addressing issues of health but as targeting more general social welfare.

Ring-fencing some funds for certain social groups was seen in the policy design of all countries except Germany. Both NZ and Irish policy began with funding exclusively reserved for certain social groups. NZ moved to a partly universally accessible fund and then returned to the entirely socially focused structure, while the UK and Ireland typically reserve around half of funds for social priority groups. This policy design correlates well with the emphasis on health in NZ, the shared platform of carbon and fuel poverty in the UK and Ireland and the lack of recognition of the health benefits or fuel poverty in Germany. National recognition of health benefits can also partly be seen in the approaches to policy assessment in the different countries; distinct quantified evaluation of the health benefits in NZ, health as a non-quantified wider impact in the UK and Ireland, and no recognition in the German policy evaluation.

The policy problems of fuel poverty and public health can be targeted by retrofit support, but governments also regularly use methods of income support, or fuel subsidies to achieve the same ends. Some form of this policy exists in each of the case studies, but in Germany its existence was used to partly explain a lack of attention paid to fuel poverty and health benefits. Wohngeld policy which provides a heating allowance for some German citizens, coupled with a building stock that is considered to have better thermal properties than the other case studies could explain the lack of any socially focused retrofit funding in Germany. The lack of association between retrofit policy and fuel poverty or health benefits in Germany, should not however be seen as there being necessarily a lack of fuel poverty in Germany (Thomson and Snell, 2013; Schultz, 2015).

The recognition of retrofit policy as a means of supporting or creating employment was keenly felt at different times in Germany, Ireland and New Zealand. The use of the CBRP scheme in Germany as a means of supporting employment and facilitating economic activity is well documented (Kuckshinrichs, Kronenberg and Hansen, 2010; Jülich, 2011; Schröder *et al.*, 2011; Rosenow, 2013). The substantial increase in retrofit spending in Ireland in 2009-10, in contrast to the general reduction in public spending, is striking. In both the NZ and Irish examples, the use of the retrofit spending for jobs argument had greater political traction around the time of 2008-2010. In Ireland where recessionary impacts were more pronounced than they were in NZ, the arrival of significantly increased spending on retrofit in 2009-10 were linked to efforts to ‘do something about unemployment’ (4a). In NZ, the process of making retrofit policy reality was fraught and was ultimately also aided by economic concerns and the job argument being made. Party politics also played a role in both Ireland and NZ where the respective Green Parties were heavily involved with the promotion of retrofit policy. In Germany, the association of employment and retrofit has been relevant outside of the 2008/09 recession, and can be attributed to a political culture of supporting jobs with public policy and the strong voice of the construction sector at a time of declining sectoral employment (Sommer and Rosenthal, 2012; Rosenow, 2013). It is also appropriate to note the characterisation by Hall and Soskice (2001) of Germany as a Co-ordinated Market Economy, as opposed to the Liberal Market Economies of the UK, New Zealand and Ireland. Estimates of jobs supported by retrofit policy are a regular feature of UK IAs, but overall the employment benefit was not viewed as having as much traction in the UK as in other countries. The idea of a single policy resulting in a net employment increase was seen as being met with scepticism by the government treasury (1a, 1b).

Benefits to a country's energy security is arguably the least tangible of the benefits considered here, and thus recognition of it as a rationale for policy can be more difficult. There is repeated mention of retrofit policy maintaining the security of energy supply in all recent policy IAs in the UK, there is one mention in the evaluation of Irish policy, no mention in the evaluation of the impacts of the WUNZ policy or in the KWZ evaluation of the CBRP scheme. In interviews, respondents from NZ all agreed that there was next to no connection between retrofit policy and energy security, largely due to the state of domestic energy sources. While in the UK and Ireland it was considered of some importance – largely due to limited domestic energy resources – but was only considered in one interview (1d) to be a primary motivation for retrofit policy. In Germany it was considered to be of only passing relevance to retrofit policy, at particular moments of pronounced geopolitical tension (2a, 2b, 2c). Despite its secondary nature in German rationale, it was clear from German interviews and literature sources that there is a link between the generally positive political consensuses around EE policy, and historical events such as the oil crises of the 1970s (Duffield, 2009;

Hake *et al.*, 2015). Germany has been reliant on foreign sources of energy for longer than, for example, the UK, potentially helping to build an implicit belief that policy support for EE is worthwhile.

Table 2: Policy rationale: summary of findings

	Policy rationale
UK	Carbon and fuel poverty provide the primary rationale.
Germany	Carbon provides the primary rationale for policy, and is joined by the employment/economic activity rationale.
New Zealand	The health benefits provide the primary rationale, supported by the employment and carbon policy problems.
Ireland	Carbon and fuel poverty provide the primary rationale, supported by the employment rationale.

Each case study considered here offers a distinctive mix of benefits connected to the retrofit policy solution. With the exception of energy security each benefit has at some point had significant influence on the existence of policy. The countries which demonstrated tangible recognition of the most benefits – NZ and Ireland – also demonstrated the smallest amount of funding support for retrofit. This limited evidence would suggest that the relationship between the number of benefits recognised in the overall rationale, and the level of policy support, is much more nuanced than multiple benefit recognition simply resulting in multiplied policy support.

Whether or not there is a limited space for different benefits to be recognised within the overall rationale or a 'problem load' capacity for a single policy solution, is difficult to ascertain as when there was less recognition of a particular benefit there was often a fitting explanation for this. The two countries with the greatest per capita funding and also those highlighted as front-runners in overall retrofit policy (Murphy, Meijer and Visscher, 2011), the UK and Germany, had significant benefits missing from their rationale – employment/economic benefit in the UK and fuel poverty/health in Germany. The promotion of retrofit as a form of infrastructure in the UK, and work to highlight the existence of fuel poverty in Germany may help to shed light on the extent to which currently unappreciated benefits of policy can be added to a policy's rationale and to what extent this might affect overall policy support. The influence of different benefits at different times offers a further level of complexity to the multiple benefit framing. The employment benefit was most commonly recognised during the 'trigger point' or 'focusing event' (J. Kingdon, 1995; Pralle, 2009) of a financial recession. While more overtly social benefits like carbon emissions and fuel poverty demonstrate a more gradual recognition, in line with the idea of subsystem spill overs (Rosenow, 2013).

With regards to the form of overall rationale, as mentioned we have limited case studies and cannot draw strong conclusions from our analysis on the nature of the relationship between the overall rationale for policy and the level of policy support. It is, however, interesting to note that the German example, which had the most consistently economic rationale, also had the most celebrated retrofit policy package (Murphy, Meijer and Visscher, 2011) - high levels of national funding, significant non-financial policy intervention and higher levels of leveraged private investment from a predominantly loan-based system. New Zealand, which had the most identifiably social rationale for policy, had the lowest funding, and relatively minor non-financial policy instruments. From this it could be inferred that a policy framed as offering some return on investment, may be more attractive to a wider range of policy makers, and thus allow for greater funding and wider policy support. Another interpretation would be that it was the lack of association with the carbon policy problem in NZ that resulted in the lowest funding per capita. There are, however, too many influences on policy formation to make strong claims about causes and effects and arguably, in energy policy "the best that can be hoped for is the identification of partial regularities that hold for only a limited period of time" (Sorrell, 2006).

2.6. Conclusions and policy implications

With rising calls for political recognition of all of the prospective benefits of energy efficiency, this paper seeks to assess the extent to which a selection of these benefits have formed part of the rationale for energy efficiency retrofit policy in a selection of different policy contexts. In the countries considered here, with the exception of NZ, the carbon emission benefit has probably been the predominant rationale. It has, however, normally sat alongside at least one additional benefit in the overall rationale for policy. In the UK and Ireland, concerns around fuel poverty have existed alongside the carbon benefit, with it not always being clear which the bigger influence is.

The case of NZ, where health benefits rather than fuel poverty have been the main rationale used, demonstrates that the process of recognising policy benefits is complex. Both the health benefits and fuel poverty are of limited relevance in Germany, a country considered to be a world leader in retrofit policy. The persistent connection of retrofit with employment and economic impacts in Germany, generating more of an economic rationale for retrofit policy, could help explain why there is a greater political consensus around retrofit policy there. Alternatively, the recognition of benefits could result *from the* consensus, with less political contestation resulting in a wider appreciation of some of its economic effects.

Actors looking to promote retrofit represent different interest groups – for example climate activists, fuel poverty campaigners and construction industry lobbyists - but share a common goal of retrofit policy support. The evidence considered here suggests that there is room for the retrofit policy solution to be associated with multiple policy problems, but that there may be temporal limitations on when benefits can gain traction. Advocates of retrofit policy should bear in mind that recognition of benefits may be fleeting and that a policy being associated with many different benefits may not generate multiplied policy support

Advocates may also want to consider whether the overall rationale for retrofit frames it more as economic or more as social policy. In a context of austerity or neo-liberal governance, policy that is more ostensibly associated with a financial return may be more attractive to governments with limited budgets and other priorities.

Ultimately policy contexts are thoroughly unique, and political recognition of benefits is at least as dependent on the political and cultural context as it is on the level of evidence presented. Further work should look in detail at particular countries and perform a finer grained analysis of the politics and the use of evidence in different countries over time, considering what benefits had relevance with which political administrations, when and why. Analysis of the relationships between policy mechanisms and benefit perceptions – such as loans and jobs in Germany, and grants and fuel poverty/health elsewhere - is not one properly considered here but is something that could help to shed light on the relationship between policy rationale and policy. With the influence of evidence on policy, and resultant policy responses, routinely scrutinised and frequently contested, this analysis seeks to draw attention to the related issue of how a particular policy response can be rationalised in different ways. How the overall rationale narrative for policy is framed may have an influence on a policy's prospects, and thus the analysis here should have relevance to actors working in a variety different policy areas.

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3. Holistic Narratives of the Renovation Experience: Using Q-methodology to improve understanding of domestic energy retrofits in the United Kingdom

Abstract

The energy efficient retrofit of existing building stocks can help to address various social, economic and environmental objectives. As the most cost-effective and least disruptive retrofit options have regularly been implemented as a priority, initiatives that seek to encourage continued retrofit are likely to require thoughtful improvements in their design. Understanding the population of households that may be interested in retrofit as a heterogeneous rather than a homogenous group is a critical part of improving support for retrofit. In this research, we use Q-methodology to disaggregate the home owner-occupier population of the UK and create narratives that represent their experience of home renovations. The narratives present a holistic perspective by incorporating a comprehensive range of the influences on the renovation experience. The developed narratives – 'Organised and seeking greater comfort', 'Settled and performing a functional upgrade', 'Growing and needing a family home' and 'A lot to do and no time like the present' - provide the opportunity to better understand those making renovation decisions and subsequently develop more appropriate interventions to promote retrofit.

3.1. Introduction

In countries with low demolition and construction rates it is anticipated that the currently existing housing stock will constitute the majority of the future stock for many years to come (Royal Academy of Engineers, 2010; Schröder *et al.*, 2011). The rationale for government policy and other initiatives that encourage the energy efficient retrofit of existing buildings can stem from a number of different social and economic objectives including reducing carbon emissions, addressing fuel poverty, and supporting employment (Kerr, Gouldson and Barrett, 2017). Whilst it can help achieve various social, economic and environmental goals, retrofit also offers private benefits to a building's owners and occupants, through the potential for reduced energy bills and increased property value, with investment in retrofit often coming from a mix of public and private sources (Washan, Stenning and Goodman, 2014). Policy interventions regularly involve public funding being made available with the intention of leveraging the maximum possible private investment (Rohde *et al.*, 2014). The potential longevity of existing built environments and the various public and private reasons for retrofit mean that the potential scope for implementation can be substantial.

While a wide variety of policy interventions promoting its uptake have been introduced, household demand for retrofit has been viewed as remaining stubbornly low in the face of these advances (RAP, 2010; Egger, 2015; Kastner and Stern, 2015; Pettifor, Wilson and Chryssochoidis, 2015; Bonfield, 2016; Rosenow and Eyre, 2016). Many countries exhibit a housing stock that is majority owner occupied (Meijer, Itard and Sunikka-blank, 2009), with this form of tenure resulting in particular challenges when it comes to retrofit advocacy (Gram-Hanssen, 2014b). Retrofit support measures that have been successful, have often, understandably, prioritised the most cost-effective and least disruptive opportunities. This approach, however, means that future retrofit opportunities are necessarily more expensive and more technically difficult than those of the past (Jones, Lannon and Patterson, 2013) – raising questions over the facilitation of household demand for ongoing or deeper retrofit in the longer term. Research that seeks to inform the design of retrofit policy interventions has raised a number of criticisms of current approaches. It is frequently argued that policy intervention design too often conceives of household decision making as a solely technical and economic calculation, which is too removed from the social context. As a result, the introduction of more information on, and improvements in, the value proposition for retrofit have been presumed sufficient to achieve large scale behavioural change (Galvin and Sunikka-Blank, 2014; Gram-Hanssen, 2014b; Judson and Maller, 2014; Wilson, Crane and Chryssochoidis, 2015).

Behavioural research seeking to overcome the perceived short-comings of current retrofit policy interventions has generated a variety of recommendations. It has been suggested that conceptualisations of the decision-making process should be more *situated* within the social context of everyday domestic conditions, with a better appreciation of the different types and levels of influence that might affect a household's actions at different times (Wilson, Chryssochoidis and Pettifor, 2013; Bartiaux *et al.*, 2014; Kastner and Stern, 2015; Wilson, Crane and Chryssochoidis, 2015). It is the view of some authors that current policy sees retrofit activity (energy-related renovations) as unnecessarily distinct from other forms of home renovation i.e. amenity renovations (non-energy related renovations), and that this distinction further decontextualises retrofit (Wilson, Crane and Chryssochoidis, 2015). It is regularly suggested that policy design would benefit from a more disaggregated, heterogeneous interpretation of the potential retrofitting population. (Wilson and Dowlatabadi, 2007; Steiss and Dunkelberg, 2012; Hoicka, Parker and Andrey, 2014). The details of a population's diversity in terms of personal and contextual influences like property type, tenure and socio-demographics are regularly reported, but there are currently limited attempts to understand population diversity in terms of the subjective viewpoints and experiences of households.

In response to these observations this analysis seeks to achieve a more *holistic and heterogeneous* understanding of the home owner occupier population, by carrying out a Q-methodological analysis of households that have recently been through a process of home renovation. Using a collected 'concourse' of statements that are taken from household's lived experience of the renovation process, we seek to develop a selection of representative household renovation narratives, considering both households that have had a focus on energy renovation (retrofit) and those that have not. Operating on the premise that households going through the process of home renovation are, to greater or lesser extents, subject to a wide variety of influences, we seek to create Gestalt (holistic – meaning is achieved via an appreciation of the whole, rather than the component parts) representations of the home renovation experience. Instead of assessing the relevance of *a particular influence* on a population as a whole, we use *a collection of the potential influences* on behaviour to develop narrative descriptions of households going through a process of renovation.

The paper begins with a summary of the background literature that helped to inform the research. This is followed by an explanation of why Q-methodology was deemed a suitable method for the analysis and the details of the research process itself. We then go on to use the concourse of statements to describe the renovator narratives developed. Finally, we reflect on the developed narratives and consider their implications for future retrofit support and research.

3.2. Background

3.2.1. Retrofit and policy interventions

Analyses that have considered the technological and economic feasibility of retrofit routinely conclude that the technology is well established, with much of it demonstrating a cost-effective economic case for implementation (UNEP, 2009; EC, 2011; IPCC, 2013). These findings help to contribute to retrofit being considered a logical priority in low carbon transition pathways (HM Government, 2009), and often as the preferred means of addressing fuel poverty in the long term (Middlemiss, 2016). With many countries exhibiting housing stocks that are majority owner-occupied (Meijer, Itard and Sunikka-blank, 2009; Eurostat, 2011), efforts to retrofit have to obtain the consent and collaboration of the home owner-occupier population. It has, however, been observed for some time, that technical feasibility and economic cost-effectiveness are not sufficient conditions for large scale consumer investment in home improvement (Munro and Leather, 2000; Gillingham and Palmer, 2014; Gram-Hanssen, 2014b).

The ambitious nature of climate change policy, the longevity of existing buildings and the current levels of energy use in buildings, mean that potential for energy efficient retrofit is substantial. In attempts to stimulate demand for retrofit, interconnected policy packages containing a variety of measures have been implemented with varying degrees of success in different national contexts (RAP, 2010; Murphy, Meijer and Visscher, 2011; BPIE, 2014). Due to the prevailing liberal approach to economic governance in many national contexts (Klein, 2015; Elliott, 2017), and the private nature of people's homes, retrofit policies that focus on the actions of households have tended to favour market mechanisms and information based systems, over regulations that enforce household behaviour change (Ricardo-AEA, 2015; Gillich, Sunikka-Blank and Ford, 2017b).

A prioritisation of cost-effective retrofit measures in the policy packages of many countries (EC, 2010) has seen the most economically and technically achievable measures being addressed first e.g. loft and cavity wall insulation. Cost-effective prioritisation or 'cherry picking' of measures (Sweatman and Managan, 2010) can create a 'lock-in effect' (Paulou *et al.*, 2014) with future retrofit becoming progressively more expensive, more difficult and less attractive (Galvin, 2010; Jones, Lannon and Patterson, 2013). There are thus concerns in many countries that existing policy efforts are not sufficient to meet long term targets (Egger, 2015). Particular concern relates to low levels of household *demand for* retrofit, with policy perceived to influence the decisions of those already interested, but not able to convert those currently unenthusiastic about retrofitting their property (Rosenow and Eyre, 2013a).

3.2.2. Policy intervention research

Policy interventions to promote retrofit are informed by studies of decision making and behaviour that can draw on a variety of different theoretical perspectives. It is argued that policy interventions in the recent past have frequently been heavily influenced by rational choice interpretations of behaviour (Wilson and Dowlatabadi, 2007; Maller and Horne, 2011). Such conceptualisations present actors as generally rational and self-seeking, and with sufficient agency to seek out cost-effective economic opportunities (Hobson, 2002; Jackson, 2005). Policy that emanates from this view, therefore, focuses on improving the overall value proposition of retrofit and on offering more information on the costs and benefits of retrofit. It has been regularly argued that such approaches to policy frame opportunities as overly financial, do not properly take account of the non-monetary influences on behaviour, and treat the social context within which decisions are made as of relative insignificance (Shove, 1998; Ackerman, 2008; Wilson, Crane and Chryssochoidis, 2015).

Behavioural economics research informs us that not only do people regularly behave in ways that contradict rational choice expectations (Tversky and Kahneman, 1981; Kahneman, 2011), but that they are often reluctant to even enter into substantive decision-making processes (Gigerenzer and Todd, 1999). Social Practice Theory sees individuals as no longer the focus of enquiry and instead as a "crossing point for practices" (Karvonen, 2013; Bartiaux *et al.*, 2014; Judson and Maller, 2014). Under such a view, it is argued that retrofit should not be regarded as a social practice in its own right, but instead should be viewed as a "bundle of still separate practices such as installing an efficient boiler or insulating a roof" (Bartiaux *et al.*, 2014). Sociological interpretations consider individual behaviour and resultant energy demand to be more a result of the socio-technical context than individual agency. It is therefore suggested that attempts to influence behaviour by increasing the information available on possible options, or by tinkering with the overall value proposition of retrofit, as of distinctly limited potential (Wilson and Dowlatabadi, 2007).

Many variables have been considered as possible explanatory influences on retrofit behaviour and decision making, with influences able to be conceptualised in a number of different ways. Carrying out a review of studies that considered the decision making process involved with 'energy-relevant investment', Kastner and Stern (2015) contend that the most commonly assessed explanatory variables - demography, housing type, location and decision maker disposition – are of less explanatory importance than the variables less commonly assessed, notably those relating to expectation of consequence – financial, comfort, environmental changes that are associated with the action. Meanwhile, contrasting different theoretical approaches to the process, Wilson et al (2015) observe that influences are often split between those that are personal – for example, attitudes and beliefs, or relevant experience and skills - and those that are contextual – for example, household and property characteristics. It is suggested, however, that these are only the immediate or proximate influences on behaviour, and that to appreciate the ultimate influences, research must be better situated within "the conditions of domestic life" (Wilson, Chryssochoidis and Pettifor, 2013). It is argued that it is from imbalances and tensions within these conditions of life – a household's vision of their home, their additional commitments and the inspiration they take from others - that ultimately influence the decision to renovate.

3.2.3. Retrofit, renovation and a heterogeneous population

In further attempts to alter the framing of retrofit, behavioural research comparisons have been drawn between the process of renovating for non-energy purposes (amenity renovations) and energy renovations (retrofit) (Steiss and Dunkelberg, 2012; Wilson, Crane and Chryssochoidis, 2015). Existing social norms are considered to have a greater influence on amenity renovations (Wilson, Chryssochoidis and Pettifor, 2013), with energy renovations, in contrast, currently considered a "discretionary investment" (Urge-Vorsatz *et al.*, 2012). It has been observed that investment in amenity renovations, involving minimal policy incentive, has historically far outweighed that in retrofit (Killip, 2008). It is argued that their popularity is related to the "aspirational" or "fashion and lifestyle" appeal of amenity renovations, with energy renovations more commonly made out of necessity (Gram-Hanssen, 2014a). The greater 'visibility' of some renovations is suggested as a critical factor, with renovators potentially applying higher short term discount rates and thus preferring the immediacy of renovations they can see (Wilson and Dowlatabadi, 2007).

Various authors contend that energy renovations should not be seen as distinct from amenity renovations, and that much more often than not, energy renovations will take place alongside amenity renovations (Wilson, Chryssochoidis and Pettifor, 2013; Gram-Hanssen, 2014a; Wilson, Crane and Chryssochoidis, 2015). Both energy and amenity renovations are ultimately considered to stem from similar influences, and can be seen as 'adaptive responses to misalignment within certain conditions of domestic life' (Wilson, Chryssochoidis and Pettifor, 2013). Many authors rightly observe that *both* amenity and energy renovations should not be conceived of as one-off events, but rather as processes or as a "continuous activity" (Wilson, Chryssochoidis and Pettifor, 2013; Fawcett, 2014; Gram-Hanssen, 2014a;

Pettifor, Wilson and Chryssochoidis, 2015; Simpson *et al.*, 2015). It is argued that connecting energy renovation with amenity renovations could be an effective means of increasing retrofit activity (Janda, Killip and Fawcett, 2014; Wilson, Crane and Chryssochoidis, 2015).

Within behavioural research on both amenity and energy renovation there are regular calls to view households not as a monolithic group but rather as heterogeneous, in a similar vein to that of a consumer market segmentation (Wilson and Dowlatabadi, 2007; Steiss and Dunkelberg, 2012; Hoicka, Parker and Andrey, 2014). With a variety of potentially favourable consequences from retrofit, the perceived over-emphasis on its financial impacts is seen as an example of households being treated with a lack of differentiation, and that this doesn't engender widespread participation or uptake (Wilson and Dowlatabadi, 2007).

Segmentation analysis can be seen as a useful marketing tool and as a means of improving the appeal of policy (Moss and Fleisher, 2008; Sutterlin, Brunner and Siegrist, 2011). Existing research that attempts to segment the amenity renovation, or retrofit population specifically, includes Mortenson et al (2016), who divide Danish households into the broad categories of young and old – with the young thought to be the more interested in renovation. Munro and Leather (2000) who, via a set of interviews with home owners in the UK categorised renovators by their demographics, tenure, type of activity and motivations, with categories ranging from 'young households' to households coming to the end of their lives. Fawcett and Killip (2014) disaggregate 'Superhome' retrofitters in the UK into those that are planned and those that are more emergent. Haines and Mitchell (2014) meanwhile use a 'persona-based approach' to create 'archetypes' of home renovator. While considering only a sub set of renovators – owner-occupiers of solid walled dwellings – their focus on the motivations for the renovation and on what the renovation was meant to achieve, reveals considerable diversity. Personas range from those that have been 'stalled' in their ability to carry out work, to 'idealist restorers' that are willing to take on a large project.

As a result of calls for both a more situated understanding of influences on household renovation behaviour and a heterogeneous appreciation of the renovation population, our analysis uses Q-methodology (Q) to create narratives of home renovators. The following section describes some of the theory behind Q and why it was chosen for the analysis.

3.3. Q methodology: developing holistic narratives

Q is seen as a method of studying subjectivity in “a structured and statistically interpretable form” (Barry and Proops, 1999). It operates on the premise of ‘finite diversity’ or that between individuals there are ‘shared experiences’ or ‘patterns of belief’ (Addams and Proops, 2000). Q is conventionally used to reveal subjective viewpoints that relate to a particular political or social issue. To achieve this a ‘concourse’ of statements that are considered to be representative of the ‘volume of discourse’ on a particular issue, is gathered. A purposively selected group of participants each sort these statements on a grid in a structured manner according to a spectrum of opinion (for example, from agree to disagree, or, from most important to least important) in relation to their subjective viewpoint. A participant’s arrangement of statements is termed their Q-sort. A study’s collected Q-sorts are used as quantitative data within a factor analytic process to develop a set of *shared viewpoints or narratives* that exist within a population. It is not known what proportion of the population the developed narratives represent merely that they exist to some degree, within that population.

By utilising a concourse of statements that relate to the experience of home renovation, we seek to carry out an analysis that is better situated within the broader context of the process of home renovation. The set of statements (the Q-set) used in this analysis were chosen to allow any household engaged in home renovation to satisfactorily describe their experience. The chosen statements relate to, but may not directly correspond with, the relevant conditions of daily life, the expected consequences of action, and some of the personal and contextual influences that affect renovating behaviour.

Q is considered a cross between quantitative and qualitative research and to lie between open and closed research methods (Ramlo and Newman, 2011). It is used to create Gestalt interpretations and is therefore, fundamentally interested in the whole pattern, with individual component parts (statements relating to the renovation experience) only having meaning when they are related to the other parts of the entire configuration. Rather than intending to shed light on the influence of single variables within the renovation experience concourse, we instead seek to create representations of the *whole renovation experience*; a holistic rather than atomistic approach (Watts and Stenner, 2012). We seek to improve the understanding of renovating behaviours by using Q as a means of "combining the economic and sociological bases for behaviour"(Wilson and Dowlatabadi, 2007). By incorporating a broad range of explanatory variables we seek to see "explanatory variables compete" with the intention of reducing bias in research findings (Kastner and Stern, 2015). The statements in our concourse intend to bring together the *proximate influences* on renovation – the influences on renovation, once the intention to renovate is formed - with the *ultimate influences* on renovation - the conditions of daily life that explain the formation of the intention to renovate (Wilson, Chryssochoidis and Pettifor, 2013; Kastner and Stern, 2015; Wilson, Crane and Chryssochoidis, 2015).

3.4. Methods

3.4.1 Gathering the concourse

The concourse involves a "set of statements that represents the sum of discourse on the research topic" (Pg 414 Eden et al., 2005). The composition of a particular concourse will often only be defined by the research process, and not have been set out anywhere beforehand (as is the case with our concourse) (Watts and Stenner, 2012). To gather the concourse, 40 interviews with home owners that had some experience of home renovation were carried out, producing a pool of over 500 statements. Interviewees were identified via public advertising, contact with local renovation interest groups and a subsequent 'snow balling' technique. As previously highlighted there is a considerable grey and academic literature that looks at the possible influences on renovation decision making, both for amenity and energy renovators (Munro and Leather, 2000; Earl and Peng, 2011; Fawcett and Killip, 2014; Haines and Mitchell, 2014; Kastner and Stern, 2015; Wilson, Crane and Chryssochoidis, 2015; Sunikka-Blank and Galvin, 2016). The pool of statements from the interviews were compared with this literature to ensure a comprehensive concourse.

Our concourse was gathered using the framing of "the conditions of daily life, expectations of consequence and personal values that influence the act of home renovations". This framing was developed in line with the observations that "household characteristics do not help explain renovation intentions directly, once other influences are taken into account" (Wilson, Chryssochoidis and Pettifor, 2013), the view of Kastner and Stern (2015) that explanatory variables relating to *expectation of consequence* are more relevant than those of housing type, location and demography, and Wilson's (2015a) contention that the *conditions of daily life* "emphasise the ultimate influences that originate and shape the decision process". The statements considered do not necessarily specifically represent a condition of daily life, an expectation of consequence or a value, and may instead cut across these descriptions. The ultimate aim of the selected statements was to allow the renovator to satisfactorily describe their renovation experience. Additional contextual data relating to household demographics, house type, tenure and the form of renovation, were collected prior to the Q-sort process.

3.4.2. Refining the concourse and selecting participants

The initial pool of 500 statements was refined to a smaller set that is considered to broadly represent the full volume of discourse. The smaller, refined set of statements is referred to as the Q-set. The gathering of the initial pool of statements and the construction of the refined Q-set can often make up the bulk of research time (Watts and Stenner, 2012).

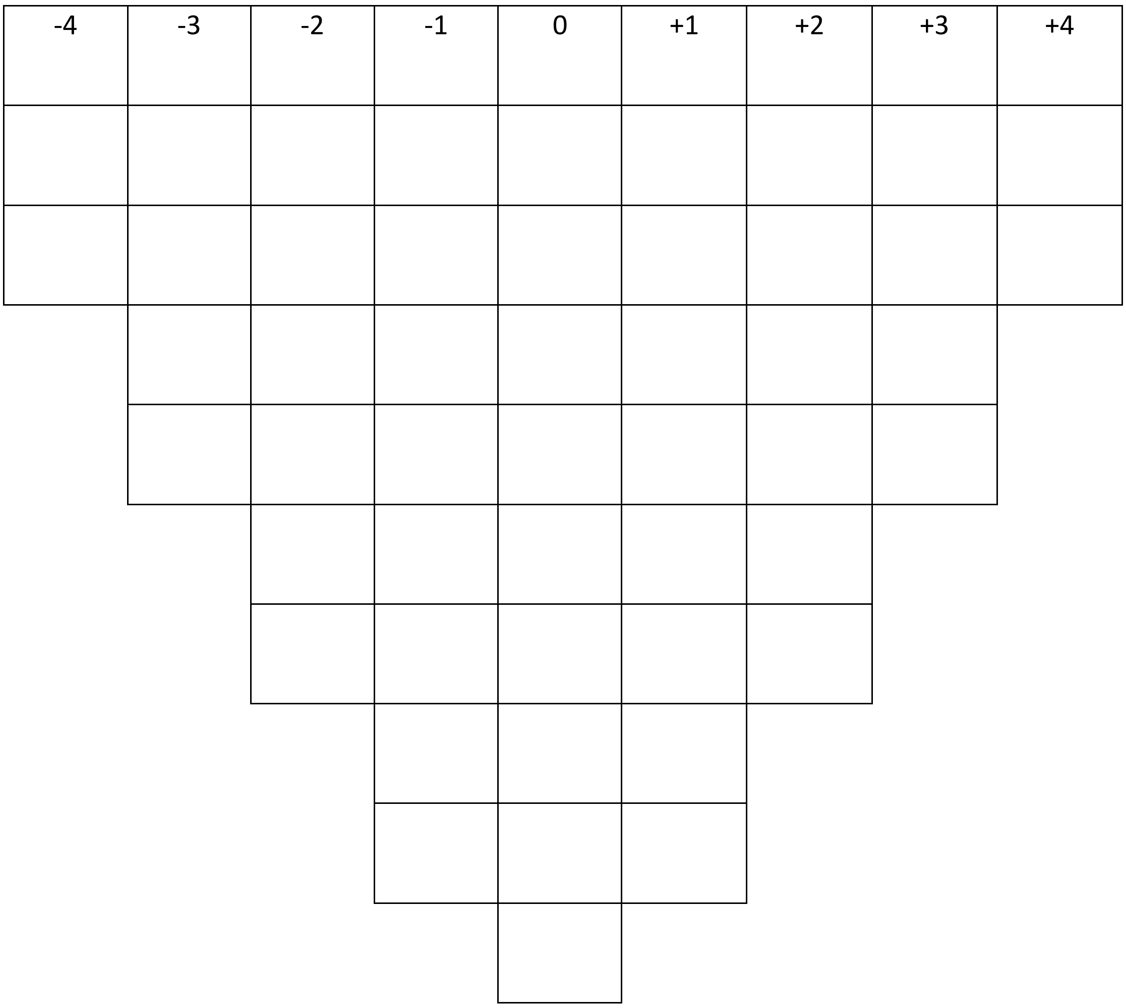
To refine the initial set, the 500 statements were categorised into groups representing similar sentiments, and thus multiple statements considered to be pertaining to the same sentiment are refined to a single representative statement. At first statements are recorded verbatim, but then, if necessary, they are edited so that they are comprehensible to any potential participant. Our final Q-set contained 49 statements.

Participants (the P-set) sort the refined set of statements (the Q-set) in a pre-defined grid, shown below (Figure 2). The grid shape in our study involved a forced normal distribution in accordance with the logic generally applied in Q-studies. A normal distribution is generally favoured as it allows a less ambiguous and more convenient comparison of Q-sorts (Watts and Stenner, 2012). The final grid shape is ultimately decided by the subjective judgement of the researchers. The grid should not be too narrow so that participants are not able to distinguish between statements that they would like to, but also not too broad that they feel they are making what they find to be unnecessary distinctions. 5 pilot interviews are used to find an appropriate grid breadth as well as test the comprehensiveness of the Q-set. With a breadth that adheres to the outlined criteria and the application of a normal distribution, the size of the Q-set i.e. 49 statements, largely determines the rest of the grid shape.

Figure 2: The Q-sort grid

The shape (number of columns and the depth of those columns) was decided based on the number of statements that made up the concourse (49) and guidance from the pilot Q-sorts.

Most Disagree Most Agree



The final participants in the study, the P-set, were all home owner occupiers living in the North of England that had been through some form of renovation process in the last 5 years. We followed the interpretation of renovation used by Wilson (2015) of “substantive physical changes to a building…typically carried out by professional contractors”. In accordance with the inverted logic of Q, where the Q-set constitutes the study sample, and the participants constitute the variables, the P-set is purposively selected, in order to capture a range of perspectives that are of interest to the researcher (Durning, 1999). Potential participants were identified using a snow-ball technique, by public advertisements and collaboration with local renovation interest groups. Final participants were selected in order to ensure a diversity of households according to various demographic and property details (see Appendix for details of P-set). The P-set is not intended to be representative of the full population of households in our study area, but it is part of the logic of Q that a diverse P-set should allow for the development of a greater number of narratives.

In accordance with Watts and Stenner (2012), our analysis used roughly half as many participants - 24 - as we had statements. To ensure that the P-set contained a proportion of households that had some focus on energy renovation (retrofit), a local retrofit co-operative group was approached in order to attract participants. Of the final 24 participants, 10 came from attendees to this group's meetings, although all of the 10 also had some amenity renovations as part of their whole renovation activity. The remaining 14 were purposively selected from a potential pool of candidates identified by the techniques outlined above. Energy renovations were defined as any substantive change made in order to effect the energy consumption and/or environmental impact of the property.

3.4.3. Q-sorting

The Q-sort process was carried out face to face, with some contextual influences such as demographics, property type, length of tenure, and details of renovation, recorded prior to the sort process (see Appendix). These details were used to categorise the participants into those that had a minimal (one energy measure or less), moderate (more than one energy measure) or substantial (majority of measures) energy focus in their renovations, and whether their renovations were of minimal (one room involved in renovation), moderate (more than one room) or substantial (majority of rooms received some renovation) overall renovation level. This method of categorisation takes no account of the time, cost or disruption of the renovation, as these details were considered too intrusive to be requested from all participants. The categorisation is, therefore, of limited accuracy but should still provide some useful information on the level of renovation and energy focus of each participant.

Participants were asked to arrange the 49 statements from ‘Most agree’ to ‘Most disagree’. The research was interested in the pre-renovation influences and so the participant was asked to construct their sort accordingly. As the research was not carried out in a longitudinal fashion there is the potential for ‘post-adoption’ influences to feature in a participants sort (Wilson and Dowlatabadi, 2007). The rationalisation of a particular action is likely to be different pre and post the event. It is also possible that the changes involved with a home renovation will result in emergent attitude and behaviour changes (Tweed, 2013). Research, such as ours, that takes places after the event of interest, will contain a degree of post-hoc rationalisation which is a limitation of the study. The rationalisation that is used after a decision is likely is give undue emphasis to desirable traits e.g. care for the environment (statement 36) or organisational ability (statement 11). There is also likely to be less emphasis given to traits that may be perceived as less desirable, such as a financial motivation (statement 40) or being under the influence of others (statement 32). The post adoption rational, captured here, is likely to involve a different sorting of statements and thus ultimately different narratives than would be found if the pre-adoption rationale was able to be captured. How the eventually developed narratives would ultimately differ is, however, beyond the scope of this study.

A post-sort interview was conducted in order for the participant to elaborate on their given sort pattern. This information was used in the interpretation of the resultant narratives.

3.4.4. Factor analysis and interpretation of narratives

Factor analysis was carried out using the PQ-method software version 2.35 (Schmolck, 2002). Q operates by correlating the resultant Q-sorts with each other in a correlation matrix, and identifying similar sorting patterns. Factor extraction was carried out using Principal Component Analysis (PCA) and Varimax rotation, which involves rotating factors according to statistical criteria as opposed to manual rotation. This approach was taken as the research was not drawing heavily on any a priori theory for factor rotation.

There are various objective means of deciding how many factors should be considered legitimate viewpoints within a particular Q analysis. In this analysis we adhered to the Kaiser-Guttman criterion, Humphrey's rule and had at least three participants loading significantly on each factor at a 0.01 level. In Q, however, deciding on eventual factors is ultimately down to the judgement of the researcher, who should use their experience to assess whether a factor is able to be explained as a narrative in an interpretable manner (Watts and Stenner, 2012).

PQ-method produces 'factor arrays' – idealised patterns of a Q-sort that represents a factor. These factor arrays (see Table 3) are interpreted to create narratives. The interpretation of the factor arrays to create meaningful narratives broadly followed the systematic approach developed by Watts and Stenner (2012). The developed narratives were compared with the recorded socio-demographic, property and renovation details as well as the post-sort interviews in order to improve their overall descriptive potential. As highlighted in section 3, the developed narratives do not represent the whole population under investigation, but they should exist as recognisable narratives within this population.

3.5. Results

The analysis produced 4 renovation factor arrays that adhered to the criteria outlined in section 4.4. The factor arrays - idealised patterns of Q-sort in these factors - are given in Table 3. This shows that, for example, in the idealised statement pattern of Factor array 1, statement 1 was placed at the -4 position (the point of most disagreement).

Table 3: Positions of statements in the idealised pattern/factor array

	Statements	**Factor array 1**	**Factor array 2**	**Factor array 3**	**Factor array 4**
1	I/We were not that bothered about the look of things.	-4	0	-2	0
2	I/We wanted to make the property more attractive.	2	1	3	1
3	The house was habitable but it wasn't to my/our taste or style.	3	-1	-2	-1
4	I/We were worried the renovation would make the house look wrong.	-1	-1	-2	-1
5	I/We thought I/We would be in the house for a long time, so it was sensible to renovate.	2	3	0	1
6	I/We didn't want to needlessly waste stuff or get something new that I/we don't need.	0	1	1	1

7	I/We had some extra cash and saw renovation as a good way of using it.	-1	2	0	-2
8	I/We thought a poor installation would make it difficult to sell the house.	0	-1	0	2
9	I/We thought that it would be good for the value of the house.	1	1	2	3
10	I/We were very worried about the level of disruption involved.	-2	0	0	-1
11	I/We had a plan in mind about what should be done to the house, and when.	3	0	1	-3
12	I/We were worried that the things that needed doing were big things.	-2	1	-2	1
13	It seemed daft not to try and do everything at the same time.	2	-2	-1	-2
14	I/We wanted to carry out one renovation at a time, and not have too much on at once.	-1	1	1	-3
15	I/We only wanted to do things that were stress-free.	-2	-1	0	0
16	The scale of possible work was off-putting	0	1	-1	2
17	I/We had wanted to renovate for a while but didn’t have the time.	-3	-1	3	-2

18	I/We wanted to renovate but weren't sure what the best options were.	0	1	2	0
19	I/We weren't using the rooms/space in the house well.	0	-1	2	0
20	I/We were interested in cutting down the noise that was coming from outside.	-1	-2	0	-4
21	Creating a new space was very important.	1	-3	2	-1
22	I/We wanted to do it because of health and safety concerns.	-2	-3	-4	3
23	I/We wanted to improve the feeling of living in the house	3	2	4	2
24	I/We wanted to spend money on something that would give us pleasure.	2	0	3	0
25	To improve the comfort of the home I/We had to renovate.	4	4	2	4
26	The layout of the house was not appropriate for us.	0	-3	1	0
27	Certain rooms in the house were not liveable.	1	-2	-1	2
28	There was a major incident that resulted in renovations being needed.	-4	-1	-4	-3

29	I/We renovated because something was broken.	-1	0	-1	1
30	My/Our lives changed and I/We had more time to think about renovating.	-1	0	-1	-3
31	Changing family conditions made some renovations necessary.	-3	-2	3	0
32	I/We had a friend that had xxxxx and I/We thought it was great.	-3	-2	1	-1
33	I/We had a tradesman that I/We trusted.	0	0	1	-2
34	Because of various one-off issues, I/We decided to invest and solve the problems.	-1	1	-1	-2
35	I/We were reasonably knowledgeable about what needed done.	1	3	1	-1
36	I/We wanted to make our home greener, more environmentally friendly.	1	4	-2	3
37	The house was cold and uncomfortable.	2	2	-3	3
38	The house was old and tired and was not appropriate for us.	3	-4	-3	0
39	I/We wanted to maintain the existing appearance.	-2	2	-1	-2

40	I/We worried whether we would get the investment back if we sold it.	0	-3	0	1
41	I/We saw the work as being good for the long term future of the house.	2	2	2	2
42	I/We wanted the work to bring us an immediate benefit.	1	2	4	1
43	I/We really didn’t want to live in a messy building site	-1	0	0	-1
44	I/We normally like to maintain what we have, rather than install something new.	1	0	0	-1
45	I/We could borrow money cheaply and thought it a good idea to use it.	-2	-4	-3	-4
46	I/we worried about something going wrong with the work.	0	-1	1	2
47	I/we are quite handy and thought we had the skills to do some things ourselves.	-3	3	-2	1
48	I/we saw the renovations that were carried out on the house as a project.	4	-2	-3	-1
49	I/We were interested in reducing our energy bills.	1	3	-1	4

Below we interpret the idealised Q-sort patterns given above, and create narratives using the position of the statements in each Factor array (Watts and Stenner, 2012). The narratives make reference to the statements from which they are constructed in brackets when relevant.

3.5.1. Narrative 1 - Organised and seeking greater comfort

Narrative 1 explains 19% of the study variance and it has 7 significantly loading renovators i.e. 7 Q-sorts significantly correlated with this narrative and thus contributed the most to its factor array. Renovators in this group had a broad age range and inhabitant type, a mix of property types and property ages, while they had a disproportionate amount of significant loaders that had recently moved to the property.

Their desire to renovate is a firm, premeditated decision that has not been overly influenced by external events or trigger points (statement 28, -4; s29, -1; s30, -1; s31, -3; s32, -3). Changing family conditions (s31, -3) or the general influence of others (s32, -3) have not played a major role in their decision making process. There was minimal economic influence on the renovation rationale (s9, +1; s40, 0; s49, +1).

Improving the comfort of their home is at the forefront of their mind (s25, position +4). The house is considered somewhat uncomfortable (s37, +2), and there is a desire to improve the feeling of living in the house (s23, +3). There is also ample consideration given to the homes appearance, with the narrative fundamentally concerned with how things look (s1, -4), and interested in making the property more attractive (s2, +2). Overall they seem keen to re-invent their home, to match their ‘taste or style’ (s3, +3) and to make it more ‘appropriate’ (s38, +3). Their renovation is not overly concerned with altering the general layout (the position of walls, doorways and windows), of the property (s19, 0; s26, 0).

An important characteristic of this view is that they considered themselves to have a plan in mind for 'what should be done and when' (s11, +3), and that they viewed the house as a 'project' (s48, +4). The organised approach is reflected in the minimal time between the thinking and acting stages of the renovation (s17, -3). Their decisiveness is reflected in a desire for different parts of the project to be carried out simultaneously (s13, +2), and a general lack of concern that the work would be overly burdensome (s12, -2; s10, -2; s15, -2). They do not however, see themselves as willing to become too directly involved with the work (s47, -3).

They do see themselves living in the property for some time (s5, +2), and they felt the work would be good for the long term future of the house (s41, +2), views that may reflect the disproportionate amount of correlated Q-sorts in this narrative that had recently moved to their property. They are slightly less concerned with it bringing immediate benefit (s42, +1). They are not unduly fazed by the disruption the work may cause (s10, -2) and they are more willing than most to accept the stress that it may entail (s15, -2).

3.5.2. Narrative 2: Settled and performing a functional upgrade

Narrative 2 explains 14% of the study variance and it has 5 significantly loading renovators. Again there is a mix of ages, inhabitant types and property types. There is a disproportionate amount of the homes in the oldest category and inhabitants in the longest length of tenure category. There are also no significant loaders in the lowest income category.

This renovator has a green agenda (s36, +4), and an interest in reducing their energy bills (s49, +3). As with most energy renovators there is also a desire to improve the comfort of their home. They are similar to the first narrative in that the home is seen as somewhat cold and uncomfortable (s37, +2), with renovation necessary to improve comfort levels (s25, +4). The possibility of renovation is also at least partly facilitated by the existence of some extra cash (s7; +2), and aided by the possibility of the narrative inhabiting the home for some time to come (s5, +3).

There is not much desire to alter the existing appearance of the home (s39, +2), with aesthetic considerations generally of a secondary nature (s1, 0; s2, +1; s4, -1). The house's existing physical layout is considered appropriate and something that shouldn't be altered. There is minimal concern with the previous layout of the home (s26, -3) or how the existing rooms/space were being used (s19, -1), and there is no desire for a new space (s1, -3).

The general satisfaction with much of the home as it is prior to renovation, is again detected via disagreement with the idea that the home is 'old and tired' (s38, -4), or that it is unliveable (s27, -2).

Perhaps in keeping with the possible moral agenda of a renovator that is more focused on energy performance improvements in their home, there is a distinct lack of concern with whether there will be a return on investment from the renovation (s40, -3), but there is some acceptance that it may be good for the value of the house (s9, +1).

This narrative looks on the renovation work as something that they want to be engaged with and informed about. They consider themselves knowledgeable about what needs to be done (s35, +3), but also as capable of contributing to the work or 'having the skills to do some things ourselves' (s47, +3). This attitude is potentially related to the nature of energy renovations, which can be perceived as less conventional practice than other renovations, with less available installation expertise and thus the potential for home owners to want to have a more 'hands on' approach. They do not display any strong feelings about the scale (s12, +1; s16, +1) or level of disruption involved (s10, 0; s15, -1).

3.5.3. Narrative 3: Growing and needing a family home

Narrative 3 explains 10% of the study variance and it has 3 significantly loading renovators. All significant loaders are from the ‘Family’ category and in the age range 35-55. Property type, age and length of tenure are all mixed, while there are none of this group in the lowest income group.

Although the renovation is seen as good for the house in the long term (s41, +2), it is thought more important that it should bring an ‘immediate benefit’ (s42, +4). This benefit is related to how liveable the home seems to its inhabitants (s23, +4). Changing family conditions had a considerable influence on what work was carried out (s31, +3), with this dynamic possibly giving rise to the need for a ‘new space’ (s21, +2).

The desire for immediate benefit may be partly a result of the thinking stage of the renovation process being extended and work being delayed (s17, +3), with this postponement possibly connected to the challenges of family life. Non family trigger points are of little influence on the decision to renovate (s28, -4; s29, -1; s34, -1) and the home was not seen as a project (s48, -3). The unpredictable nature of life for this narrative is again seen with a relatively low level of agreement with the idea that they knew they would be in the house for a long time (s5, 0).

There is some feeling that the renovation would be good for the value of the house (s9, +2), and little concern that investment won’t affect their home’s value (s40, 0). Perhaps due to the limitations on free time connected with raising children and a resultant inability to carry out one’s own research, this group were the most influenced by the homes of others (s32, +1).

Although this narrative shows some interest in improved comfort (s25, +2), they are overall less motivated by comfort than others. Prior to the work the house was not considered to be uncomfortably cold (s37, -3), or old and tired (s38, -3) and it was generally considered liveable (s27, -1). This renovator feels that the space within the house could be used better (s19, +2), and that a new space is important (s21, +2). The renovation is viewed as something that should bring a tangible reward, or that it should “give pleasure” (s24, +3). They are interested in how things look (s1, -2) and there is a feeling that the home should become more attractive as a result of the work (s2, +3). There is minimal environmental drive for the work (s36,-2).

This narrative displays resolve in the face of challenging work (s12, -2), and ambivalence toward the potential disruption that might be involved (s10, 0; s15, 0). The necessity for change that comes from a developing family means that there was little possibility of this narrative being put off by the scale of the work (s16, -1). They do admit, however, to not necessarily being aware of what the best options were (s18, +2).

3.5.4. Narrative 4: A lot to do and no time like the present

Narrative 4 explains 10% of the study variance and it has 3 significantly loading renovators. This narrative had either a grown up family or there was still a family present. There was a mix of property types, ages and length of tenure. Two of the group were from the lowest income category.

Overall there is a feeling of considerable unhappiness with the property prior to renovation, with the narrative having multiple reasons for renovation. The house is viewed as ‘cold and uncomfortable’ prior to the renovation (s37, +3), and an improvement in the comfort of the home is therefore of fundamental importance (s25, +4). The home is even viewed as somewhat of a health and safety concern (s22, +3), with some of the rooms regarded as not being liveable (s27, +2). There is also a strong energy renovation influence, with a desire to reduce the cost of energy bills (s49, +4) and to make the home more environmentally friendly (s36, +3).

Despite the overall dissatisfaction, there is relative indifference to aesthetic considerations (s1, 0; s2, +1), but with there still being some desire to ultimately change the overall appearance of the property (s39, -2). They are not primarily concerned with altering the general layout of the property (s19, 0; s26, 0).

There does not appear to be as much of an impact on this narrative from influences that are external to the house itself. General life changes (s30, -3), or the possible influence of a cash windfall (s7, -2) scored lower in this narrative than in any other. In line with the other narratives, there was disagreement with the idea that they would borrow money to carry out renovations (s45, -4) or that they were looking to reduce noise pollution by carrying out the work (s20, -4). There is confidence that the work would be good for the value of the house (s9, +3) and some attention is paid to whether there would be a return on investment (s40, +1; s49, +4).

Possibly due to the overall discontentment and thus the potential amount of renovation deemed necessary, there is some trepidation about the scale of work (s16, +2; s12, +1), and a feeling that something might go wrong (s46, +2). They are the least likely to have a trusted tradesman in mind (s33, -2) and to declare themselves knowledgeable about what needed doing (s35, -1). They have a somewhat ad-hoc approach to the work, and disagreement with both the idea there was a plan (s11, -3), and that things should be done one at a time (s14, -3). Alongside this, however, they also do not believe that things should necessarily be all done at the same time (s13, -2). Despite the potential scale of the work there is minimal concern about the work causing intolerable levels of disruption (s10, -1; s15, 0).

3.6. Discussion

As highlighted, previous research on the topic of household retrofit behaviour has considered the influence of a wide variety of explanatory variables. Within this however, it is thought that there is still a need to properly “add people” into research design and policy considerations (Gram-Hanssen, 2014b).

The premise for this Q-methodological analysis is two-fold. Firstly, that every renovation experience is likely subject to the influence, to varying degrees, of numerous different variables concurrently; a household may want to reduce their environmental impact, while thinking themselves capable of some DIY, but also be unsure as to how long they will remain in their current property. Rather than atomistically studying the relevance of single variable influences, we aim to represent the sum of many influences in a holistic or Gestalt configuration. Secondly, that it is critical to understand that household experiences of home renovation will be diverse, but that this diversity will be, to some extent, finite, with some important aspects of household experience shared.

Using the multiple possible influences on home renovation this analysis reveals potential narratives for home renovators, and provides interpretations of their shared experiences. We develop our narratives by considering the influences on the decision to renovate, what the expected consequences of the renovation were and what the experience of the renovation process was.

The analysis is useful as a reflexive exercise in relation to previous studies that have considered typologies of home renovator (Munro and Leather, 2000; Haines and Mitchell, 2014). Our analysis, however, seeks to learn more general rules about renovation by focusing on a range of households and property types, as well as renovations that have both an energy and a non-energy focus.

4 factor arrays were identified with the use of the 3 objective criteria highlighted in section 4.4. These factor arrays accounted for 53% of the total study variance. Despite 47% of the study variance not being accounted for, any study accounting for above 35% is ordinarily considered a sound solution in factor analysis (Watts and Stenner, 2012). 18 of the participants loaded significantly on one of the factors, the remaining 6 Q-sorts did not load significantly on any factor - there were no confounders (sorts loading on more than one factor). The narratives developed using Q are intended to achieve depth rather than breadth. While only accounting for 53% of our sample's variance there is also likely to be additional narratives of renovation experience that could be captured from a different sample of UK households.

3.6.1 Renovation narratives

The factor interpretation stage revealed 4 factors that were considered distinct. The idealised factor arrays have been interpreted as renovation narratives in the Results section. As highlighted renovation is better conceptualised as a "continuous activity" rather than a one-off event. The participants in this analysis were households that had been through a renovation experience in the last 5 years with their sorts ordered according to their experiences. It is quite possible that a particular household may relate to more than one of the different narratives at different points in their lives.

3.6.1.1. Narrative 1 - Organised and seeking greater comfort

The first narrative describes households that expected a more comfortable home but also gave serious thought to how the renovation would affect their home's aesthetic appearance. Changing the layout of the house or how space is used is not such an important consideration. Their renovation is conceived as a project – akin to the 'idealist restorer' of Haines and Mitchell (2014) - with the household more likely to plan out what they want to do. The narrative has potential to be associated with those carrying out substantial overall renovations, where energy renovation is not a priority. It is likely to apply to those that have recently moved into a property and want to make the home feel more like their own. The potential for promoting energy renovation at the point of homeowners relocating has been observed in other studies (Lester, 2013), with a reduction in any property purchase taxes an option for incentivising energy renovation at this point. This narrative has already accepted the upheaval of a major renovation project, and it is possible that if proposed in an appropriate way, opportunities for energy renovation could be attractive. As there is an acceptance of potentially large amounts of disruption and a desire for work to take place simultaneously, the renovation is likely to be a large scale but quite isolated occurrence with additional future renovation potentially limited.

3.6.1.2. Narrative 2: Settled and performing a functional upgrade

Narrative 2 is interested in energy renovation, but, as with other narratives, improving the comfort of their home is also at the forefront of their mind. Similar to narrative 1 they are not interested in changing the layout of the property, but unlike the first narrative, they have minimal interest in altering their home’s existing appearance. They are reasonably content with their home prior to renovation, and expect to be living there for the foreseeable future. They are more likely to want to be involved with the work that is being done, both in terms of knowledge of what the work involved and potentially also carrying out some work themselves. This is a finding that resonates with the description of energy renovators in other research (Fawcett and Killip, 2014). Again, with similarities to narrative 1 this renovator is organised and premeditated and not overly influenced by trigger events. They are driven by internal attitudes and/or values, or by the ‘delineating’ condition (Wilson and Dowlatabadi, 2007; Wilson, Chryssochoidis and Pettifor, 2013).

Of the 5 participants that most correlated with this narrative, 4 have been in their property for over 10 years and all the properties are over 100 years old. There is also an absence of young children in the families of the 5 participants, a characteristic which is connected with pro-environmental behaviour in other research (Hines, Hungerford and Tomera, 1987).

Those looking to promote retrofit in terms of its multiple benefits may be interested to note that narrative 2 firmly identifies comfort as an expected consequence but they not interested in significant aesthetic alteration. The functional rather than aesthetic nature of energy renovations is highlighted by Gram-Hanssen (2014b), while in their renovator personas Haines and Mitchell (2014) outline the different characteristics of a functional and an aesthetic renovator. Although aesthetic delineation may not be a driving factor for retrofit it is important to also appreciate that home owners may be concerned that retrofit may negatively affect their homes current appearance

3.6.1.3. Narrative 3: Growing and needing a family home

The participants contributing to narrative 3 are all representatives of family households with young children. This narrative is the most influenced by 'changing family conditions' and the possible implications of the family set-up is interpreted as the ultimate influence that gave rise to the intention to renovate. The household had 'wanted to renovate for a while' and the renovation is seen more in terms of its 'immediate benefit'. Improved comfort is a consideration but the house was not considered cold, tired or uncomfortable beforehand. This narrative is focused on creating a new space or using the space in the house better - the households contributing to this narrative had all carried out work to, at least in part, create a new bedroom. The participants most correlated with this narrative tended to carry out smaller overall renovations and have minimal interest in energy improvements. Although external influences are often underestimated in self-reporting scenarios (Kastner and Stern, 2015), this narrative is the most likely to admit to being influenced in this way.

This renovation narrative is a reaction to changing family conditions. The work is more an adaptive necessity than a means of expressing identity (Wilson, Chryssochoidis and Pettifor, 2013). This state of affairs arguably means that the overall opportunity for renovation is therefore limited, and encouraging energy renovation will be more difficult than in a more proactive renovator such as narrative 1.

3.6.1.4. Narrative 4: A lot to do and no time like the present

For the fourth narrative, work is expected to improve comfort and reduce energy bills, while there is also a significant environmental imperative. Altering the layout of the property is not of particular interest to this narrative, and while aesthetic considerations are not paramount they do want to ultimately alter the existing appearance. This renovator exhibits significant concern with the state of their home prior to renovation. Certain rooms are considered not liveable, there are some health and safety concerns and the overall scale of the work is off-putting. The perceived *need for* improvement appears to be the ultimate influence for this narrative. They show the most concern for issues around return on investment and the work being good for the property's value. This narrative relates to the idea that "house owners often have a dream list of renovations they would like to do, but as there is not always time, money or other resources, and as it is not always fun to live in a house that is being renovated, some renovations are postponed and others are carried out" (Gram-Hanssen, 2014a). The potentially delayed nature of renovation in narrative 4 is comparable to the 'Stalled' personas developed by Haines and Mitchell (2014), with this persona divided into those that are stalled due to a lack of finance and those that are delayed by the pressures of life.

The considerable dissatisfaction with the current state of the home implies a desire for substantial renovation that is unfulfilled. Such a narrative could relate to new inhabitants of a property, or to existing inhabitants that have seen their property experience gradual wear and tear, and whose priorities have led to renovation being considered infeasible. Households which have recently moved into a property are regularly highlighted as suitable candidates for policy intervention, for example, with the use property purchase tax exemptions or green mortgages (Guertler and Rosenow, 2016; Hamilton, Huebner and Griffiths, 2016).

3.6.2. Summary observations

As mentioned, the narratives are an attempt at a holistic perspective of a home renovator with many influences having varying degrees of relevance to each narrative. Despite this, some determinants of behaviour are more relevant for particular narratives than others. Some narratives are driven to renovate by external reasons, like the trigger point of changing family conditions in narrative 3, while other renovators are more driven by internal attitudes and values, like the environmental considerations of narrative 2 (Wilson and Dowlatabadi, 2007). Often, however, established trigger points combine with a household's values, for example, in narrative 1 where the opportunity of relocation allowed for a household to express their identity through renovation.

Cotton (2015) considers the points of agreement and disagreement between factors as a basis for developing policy recommendations. There were some statements that were relatively consistently positioned within each of the 4 narratives. All narratives, for example, considered improved comfort to be something naturally expected from renovation, a finding that resonates with other research (Meijer, Itard and Sunikka-blank, 2009). It may also be useful to compare the narratives most associated with energy renovation i.e. 2 and 4, to those more focused on amenity renovation i.e. 1 and 3, in terms of their positioning of non-energy statements. Although 1 and 3 are renovating for quite different reasons there is a noticeable difference in these narratives desire to get "pleasure" (s24) from the work in contrast to the ambivalence of 2 and 4. There was also a hesitancy from the energy renovators to do 'big things' (s12) that was not seen from the amenity renovators. This may be symptomatic of the perceived relative difficulty of energy renovations or possibly a lower overall resolve for change on the part of narratives 2 and 4. Finally, as would be expected, ‘the look of things’ (s1) and the property’s ‘attractiveness’ (s2) were more important for narratives 1 and 3, but were still of relevance for 2 and 4.

The development of a more heterogeneous understanding of a particular population should assist with policy design in any area. Different forms of policy incentive will have a different level of appeal to different types of home owner-occupier. It is not, however, necessary to develop specific policies for specific narratives or segments of the population. Rather it is important to ensure that the developed policy package properly caters for as much of the diversity of population that exists as possible. Information on energy renovation options, such as that contained within an Energy Performance Certificate or a Building Renovation Passport, should be designed so that they have relevance to different households that have different reasons for and expected outcomes from home renovation. The narratives also have the potential to be useful for the general marketing of retrofit.

3.7. Conclusions

The objective of our analysis was to better understand the diversity of experience that is encountered by home owner-occupiers renovating their property, with a particular interest in renovations that included some aspect of energy performance alteration. The resultant 4 narratives – 'Organised and seeking greater comfort', 'Settled and performing a functional upgrade', 'Growing and needing a family home' or 'A lot to do and no time like the present' - offer insight into the diversity that exists within the experience of renovation.

The research seeks to recognise the diversity within the household renovation population, and highlight the potential utility in representing this diversity in comprehensible and recognisable segments. The diversity of households is more regularly considered in terms of contextual details like demographics and house type, and there have been limited attempts to understand population diversity in terms of narrative or viewpoints. The subjective experience of households occurs under the influence of a wide variety of variables and it is useful to conceive of these experiences in a holistic manner that incorporates the variety of influences. Q-methodology was chosen as it allows a holistic representation of the renovation experience. By forcing participants to arrange a full concourse of statements relating to their experience, we are able to reflect on the relative relevance of a wide range of the possible influences on behaviour. By taking this approach we are able to better represent both the proximate influences and the ultimate influences on renovation and, therefore, offer a novel explanatory perspective on home renovators behaviour and decisions. By considering households with a focus on general amenity renovations alongside those interested in energy renovations the narratives also importantly do not conceptualise energy renovations as distinct from general home improvements.

The resultant narratives do not encapsulate all renovators and by purposively selecting some renovators that were known to have an interest in energy renovations the study is likely to disproportionately relate to those involved with energy renovation. The narratives are unlikely to be a precise match for many individual viewpoints, and some renovating households may see elements of different narratives in their experience. They apply only to a portion of the full renovating population with potentially many other narratives in existence. Our narratives should, however, be recognisable as genuine renovation experiences, and they have some similarity to other research attempts at disaggregating households according to their renovation experience as highlighted above.

With the promotion of energy efficient retrofit increasingly identified as in need of a firmer basis in the social context of domestic life, those seeking to promote retrofit should give greater consideration to potential interventions in terms of how relevant they are to different population subsets. There is also the potential for marketing campaigns for retrofit that utilise recognisable narratives of household experience. Further research could identify particular households that relate to each of the developed narratives, and assess the relative appeal of different interventions to each of the narrative groups. Representatives of each narrative could also be considered in different, additional ways, for example, with respect to the household's attitudes and beliefs with regard to the purpose of a home. Finally, there is the potential for reflection on the research findings by using the same collected concourse of statements on further sets of households. This may allow for verification of the narratives interpreted here, as well as offering the opportunity to develop additional renovation narratives. Many of our narratives reflect understandings of the renovation process seen in previous research, for example, those triggered to renovate by changing family conditions or those 'stalled' in their renovation efforts. Our home renovation narratives add value by expanding on these previous insights and outlining a holistic view of the shared but still heterogeneous experiences of home renovation.

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4. Retrofit's Public and Private Balance of Payments: comparing the investment case for energy efficient retrofit of households and government.

Abstract

The energy efficient retrofit of existing buildings is associated with multiple benefits. These benefits can apply to both the public policy supporters and the individual private recipients of retrofit. As a result the expansion of retrofit in many countries around the world has involved a joint contribution to costs from public and private budgets. While many of the public and private reasons for retrofit are non-financial, there exists a return on investment case for both the private and public funders of retrofit. In this paper we carry out a comparative assessment of the economic investment case in retrofit for the public and private funders. Our case study considers a retrofit programme in Kirklees in the North of England and finds the investment case for the private recipient of retrofit to be stronger than the public funders. By disaggregating each investment case we exhibit how each case is contingent on a variety of variable costs and returns, with the analysis having implications for the future of retrofit funding. We highlight the existence of 'vertical-cross-subsidisation' between public and private budgets, an issue of relevance to other policy domains, where there is a mutual benefit leading to a potential joint contribution to costs between public and private funds.

4.1. Research background

4.1.1. Public and private shared contribution the cost of retrofit

In countries around the world much of the currently existing housing stock has the capacity to become more energy efficient via the retrofitting of their building fabric and/or their energy systems. This inefficiency stems in part from much of the currently existing stock being built in an era of low or non-existent energy performance standards for new buildings (Jager, 1983; Buchan, 2012; Howden-Chapman *et al.*, 2012).

Retrofitting existing homes to make them more energy efficient is linked with a variety of both social and economic benefits, and as a result is associated with various government policy objectives – for example reducing carbon emissions, lowering fuel poverty, supporting employment or improving public health (Kerr, Gouldson and Barrett, 2017). Due to these policy objectives, programmes of policy intervention are used to support the uptake of retrofit measures. The ultimate achievement of policy objectives can involve ambitious targets and potentially substantial levels of investment in retrofit – for example, an estimated £85 billion to achieve targets in the UK (Dixon *et al.*, 2013).

Policy interventions seeking to promote retrofit can be directed at the demand side – the owners or occupiers of residential buildings – or at the supply-side – the installers and manufacturers of retrofit products (Killip, 2013). Policy that addresses the demand of home owners and/or occupiers may seek to offer more information on the options for retrofit, or it may seek to enforce action through the use of regulation. Additionally, policy can seek to improve the investment proposition faced by an owner or occupier by using public funds to affect the direct, upfront cost of retrofit measures. Financial policy interventions that seek to affect the investment proposition can include grants, subsidised loans or tax incentives (Maio, Zanetti and Janssen, 2012), and will typically work in tandem with non-financial policy mechanisms, such as regulations and information schemes, within an integrated policy package (Ricardo-AEA, 2015; Kern, Kivimaa and Martiskainen, 2017).

Via the different policy interventions public funding can be used to cover all or part of the cost of retrofit, with private funds from the building’s owners or occupants typically covering the rest of the costs. Where retrofit is used as a means of addressing particular policy objectives, it is therefore, common to see a *joint contribution to the cost* of its implementation from public and private funds (Rohde *et al.*, 2014).

The public funding used to improve the investment proposition of retrofit, will typically be sourced from national or local government revenue, or from a hypothecated source, for example, energy supplier obligations levying funds from energy consumers (Rohde *et al.*, 2014). For the purposes of this paper, funding that is instigated by a public policy intervention to cover the direct, upfront cost of retrofit, whether funds come from government revenue or hypothecated sources, will be referred to as public funding.

4.1.2. The multiple, shared benefits of retrofit

While public and private funds are often combined to jointly cover *the costs* of retrofit, *the benefits* of retrofit can also apply jointly to the public and private actors, with the case for retrofit implementation regularly framed as one that offers 'multiple benefits' to both respective parties (Copenhagen Economics, 2012; Lazar and Colburn, 2013; IEA, 2014a).

The perceived multiple benefits of retrofit equate to multiple *social and economic* impacts, with these impacts often connected to the various aforementioned policy objectives (Kerr, Gouldson and Barrett, 2017). The rationale for retrofit policy emanates, to a large degree, from *social* policy objectives i.e. those that involve moral obligations connected to equitable distribution and impact. There is, however, also an *economic*, return on investment rationale for the public funding of retrofit.

The potential financial returns on investment to the public funder are suggested to come from a variety of sources. It is argued that retrofit can offer net employment gains (at least in the short term) (Blyth *et al.*, 2014a) with resultant increases in tax receipts and reduction in welfare expenditure (IEA, 2014a). On top of these effects, fiscal gains for public budgets are also forecast via the changes in private and public expenditure that result from retrofit.

Improving building energy efficiency will mean increased investment in retrofit goods and services and may mean reduced energy bill expenditure. This will result in reduced tax receipts from the consumption of energy, but increased tax receipts from investment in retrofit and the counterfactual form of consumption (Washan, Stenning and Goodman, 2014). Alongside these outcomes, there is also the suggestion that retrofitting homes could reduce public health spending. The link between cold, energy inefficient homes and physical and mental health problems is well documented (Marmot Review Team, 2011; Liddell *et al.*, 2015), and on top of the moral case that this evidence presents for retrofitting homes, estimates have also been made of the potential impacts to health budget expenditure that might occur if homes were more energy efficient (DCENR, 2011).

Like the *public funders* of retrofit, the owners and occupiers of *private households* are also presented with a variety of reasons for retrofitting their properties. The case for retrofit that is presented to households is also a mix economic and non-economic rationales. The energy bill savings that can result from retrofit are regularly used to make the economic case for action (Enkvist, Nauclér and Rosander, 2007; Kesicki, 2010). While the impact of retrofit on a property's retail or rental value is an additional component of the private economic case for investment (Hyland *et al.*, 2012; Popescu *et al.*, 2012; DECC, 2013b). These economic rationales sit alongside the non-economic rationales of potentially heightened comfort, aesthetic improvements and noise reduction, as the benefits of retrofit for the private householder. It is also the case that private recipients may attach value to some of the perceived public benefits of energy efficiency (Ward *et al.*, 2011).

Table 4: Benefits of retrofit for the public and private funders

	Economic return	**Non-economic return**
Public funder	Net employment increase, increased fiscal receipts and public health expenditure saving	Reduced carbon emissions, reduced fuel poverty, improved public health, energy security
Private funder	Reduced energy bills, increased property value	More comfortable home, health benefits, aesthetic improvements.

4.1.3. Retrofit's balance of payments: The distribution of costs and benefits from retrofit

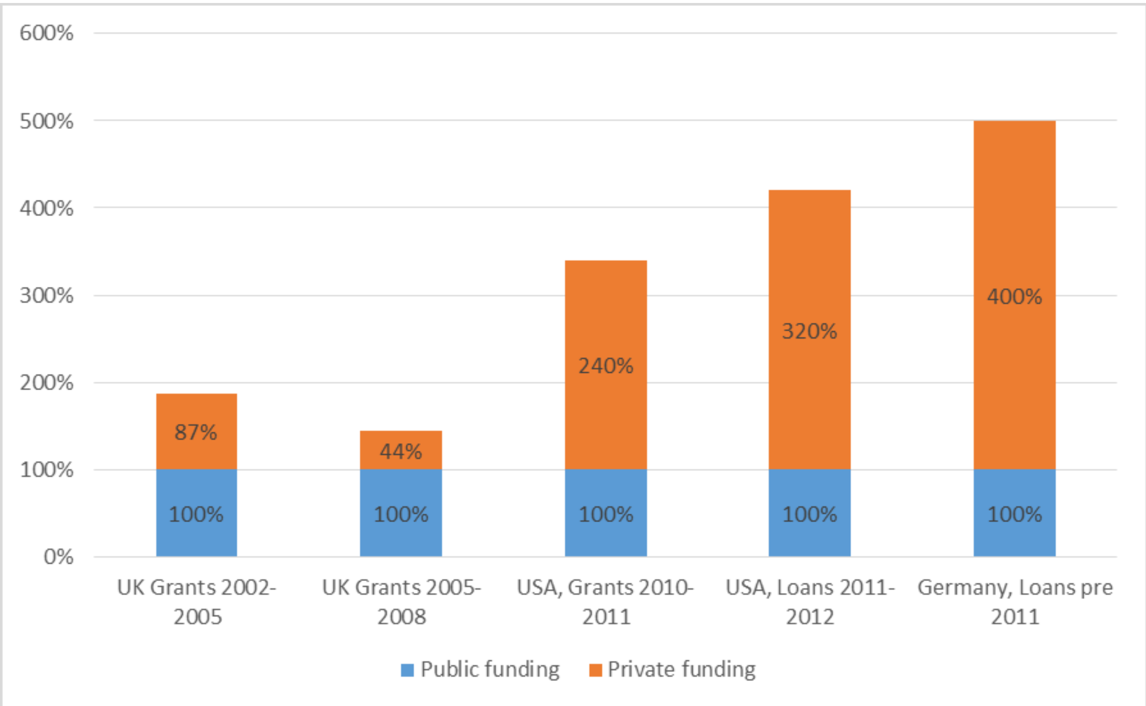
The nature of the shared benefits offered by energy efficient retrofit means that there is often a joint contribution to its costs from public and private funders in many countries around the world. While its shared benefits are to a large extent non-economic in nature, there are also substantial economic returns available from retrofit for both public and private funders. This collaborative environment of mutual cost and benefit invites questions around how the levels of investment and the returns on investment are distributed between the public and private actors.

The equitability of economic distribution with respect to energy sector transitions is an issue of increasing salience (Mitchell *et al.*, 2011; IRENA, 2014). When government interventions in a market involve the allocation of public funding as subsidies or the eschewing of public fund collection through tax reductions, these actions are unlikely to affect all members of a population equally. As a result, such interventions raise questions around equitable distribution, both with regard to where relevant funds are sourced, but also to whom relevant tax changes and subsidies are applied. Market intervention of this nature, particularly with respect to nascent industries, are a common feature of policy efforts in energy sector transition (Kempa and Moslener, 2016). Interventions to support energy efficiency or renewable energy technologies, have routinely been questioned in terms of their level of regressive cross-market subsidisation(Nelson, Simshauser and Kelley, 2011; Grover and Daniels, 2017; Strielkowski, Dalia and Bilan, 2017). Public funds for energy retrofit policies typically come from central taxation or from a levy on energy consumption. As the consumption of certain energy forms, for instance, heating fuels and electricity, are considered a necessary expenditure of the vast majority of modern citizens, extracting funds from a levy on energy consumption tends to be seen as distributionally regressive (Ekins and Lockwood, 2011). Energy retrofit policy that is funded in this way will, as a result, often have a portion of the levied funds ‘ring-fenced’ for distribution to certain priority social groups (Rosenow, Platt and Flanagan, 2013).

So far debates around equity with respect to these market interventions tend to be centred on the potential for cross-subsidisation within a population. In this analysis we seek to draw attention to the balance of ‘vertical cross-subsidisation’ between the public and private actors involved. Conventionally subsidisation is conceived of as passing from a tax collecting administrative body to a lower level actor i.e. households or firms. Cross-subsidisation involves higher costs being incurred by one group so that lower costs can be charged to another. In this paper we introduce the concept of ‘vertical cross-subsidisation’ which occurs when public policy facilitates lower costs for certain lower level actors, but these lower level actors also help to subsidise the costs of achieving government policy objectives. Such an analysis is important for a variety of reasons.

The context of collaborative funding and mutual benefit from retrofit implementation results in each party having expectations of the other with regard to the overall contribution to costs. These expectations have implications for the future of retrofit activity. Although it is difficult to accurately measure, the effectiveness of government retrofit policy can be considered in terms of how much private funding, public policy is deemed to have facilitated; the more private action that is considered to have been leveraged the more effective the policy (GfK, 2013; Gillich, 2013b; Rohde *et al.*, 2014). Figure 3 shows some of the estimates that have been made for the relative levels of private funds that have been leveraged by public retrofit schemes. There can also be a substantial gap between government targets for overall investment in retrofit and the level of public funding that is made available (Scottish Government, 2017a, 2017b). As a result there is often an implicit (or explicit) expectation from policy makers, for private investment in retrofit, in order to achieve public policy objectives.

Figure 3: Levels of leverage: private and public funding in retrofit



Refs: UK figures from (Rohde *et al.*, 2014), USA figures from (Gillich, 2013a), German figures from (Rosenow, Platt and Demurtas, 2014)

If energy efficiency retrofit is to continue to be funded, the topic of responsibility for future costs is an important one. In some future energy scenarios it is expected that private sources could invest much more in building energy efficiency improvements than public ones (IEA, 2015). Attempts to transition from retrofit scenarios with high levels of public subsidy to those with a greater private contribution to costs have so far proved difficult (Gillich, 2013b; Rosenow and Eyre, 2016; Gillich, Sunikka-Blank and Ford, 2017a). As a result there is an open question around whether a history of heavily subsidised, often highly cost-effective measures will inhibit the possibility of a future of greater levels of private investment in less cost-effective energy efficiency measures.

Finally, an analysis of the relative contribution to retrofit investment and the relative receipt of returns on investment for private and public actors is important for questions around the equity of retrofit funding support. Greater private investment in retrofit means less redistribution is required via public subsidy and thus concerns around equitable distribution are inherently lessened. While, as highlighted, cross-subsidisation is a concern within a private population, there is also the potential cross-subsidisation within public funds. The degree to which costs are incurred by one section of the public sector e.g. central tax funds, and benefits occur to another e.g. health budgets, is one which can act against appropriate levels of retrofit investment.

4.1.4. Background summary

A joint contribution to costs and a shared receipt of economic benefits means that current approaches to home energy retrofit have implications for issues of equitable distribution. In this paper we use existing estimates of the public and private economic returns that are attributable to investment in retrofit, and different scenarios for the overall public and private contributions to the costs of retrofit to model the overall balance of economic investment and returns between the public and private funders of retrofit. We consider the case study of Kirklees a local authority in the North of England.

4.2. Data and Methods

In this section we will consider some of the estimated levels of investment and returns on investment (ROI) that exist in relation to both retrofit's public (government) and private (households receiving retrofit) funders. In our final analysis we use a mix of existing estimates as well as developing some estimates of ROI specifically for this research.

We focus on national government and owner-occupier households as two of the key stakeholders and funders of retrofit in many national contexts. Although we are aware that some contexts also involve funds from local government sources, in this analysis we assume public funds to come solely from, and ROI to apply solely to national government. An investment analysis of a retrofit programme is carried out in the region of Kirklees in the North of England. Kirklees was chosen for the analysis due to the general availability of data for the region and some of the required data for the research relating specifically to Kirklees.

4.2.1. Private funders return on investment

4.2.1.1. Energy bill savings

For our analysis we use the energy bill savings estimates from the Energy Performance Certificate (EPC) data of a sample of 200 homes in the Kirklees area. The Energy Performance of Buildings Directive (EPBD) in 2002 mandated the introduction of EPCs to every member state, while the 2010 recast of the EPBD required that an EPC was attached to every property at the point of sale or rental (EC, 2010). Across Europe EPCs can vary, but in the UK an EPC displays details of the current energy performance of a property, as well as providing information on what opportunities there are for energy efficiency retrofit. These retrofit opportunities include an estimate of the cost of the action and a prediction of the potential energy savings.

As an EPC assessment is normally required to be ‘non-invasive’, the accuracy of the costs and benefits estimates within them have been called into question (Majcen, Itard and Visscher, 2013). Research on EPCs in the Netherlands, however, suggests that there may not be a unidirectional bias within an EPC findings – a study of around 200,000 properties found the energy use of higher rated properties likely to be lower than estimated, but for the reverse to be true for lower rated properties (Majcen, Itard and Visscher, 2013). Research from the UK also suggests that at an aggregated level the energy saving estimates associated with EPCs may be more accurate than that provided by individual EPCs (Adan and Fuerst, 2015; Phil Webber, Gouldson and Kerr, 2015)

Whilst acknowledging the limitations of EPCs, our analysis sourced a representative sample of 200 properties from Kirklees from an open government data base (DCLG, 2017). The sample was representative of Kirklees in terms of property type and property age (Energy Saving Trust, 2017).

Our analysis imagines a retrofit programme that moves each of the properties in the sample from their *current* EPC energy rating to the *potential* rating given on the EPC. We consider only E/D/C rated properties due to the lack of data available for the lowest rated properties – F/G – and the lack of need for retrofit in the highest rated properties – A/B. The E/D/C rated properties in the sample could see a variety of measures including cavity wall, external solid wall, loft and floor insulation as well as new double glazing, a replacement boiler and low energy lighting. The 200 home sample entails one *round* of investment in retrofit upgrades. The level of costs and savings included in each round of investment is repeatedly recycled until the available funding from the policy scenario is used up.

4.2.2. Property value change

As an information-based policy tool designed to raise awareness of the benefits of energy efficiency in buildings, there is an inevitable research interest in the salience of EPCs with respect to those looking to buy or rent property. In the earlier stages of EPC implementation, some research found there to be a limited impact on purchase and/or rental price negotiation and decision making (Fuerst and McAllister, 2011; Watts, Jentsch and James, 2011). More recent research suggests that those interested in property purchase or rental are beginning to better appreciate the findings of EPCs, and that this is being recognised in sale and rental prices (Popescu *et al.*, 2012; Hyland, Lyons and Lyons, 2013; Fuerst *et al.*, 2015). Findings such as these have helped to add weight to the idea of green finance or mortgages, where the energy performance of a building is better reflected in the terms of a loan, with preferential terms being offered to properties that are more energy efficient (Hamilton, Huebner and Griffiths, 2016).

In the UK the government department responsible for energy commissioned a study that assessed the impact on property sale value of EPCs (Fuerst *et al.*, 2013). Using hedonic regression modelling techniques the study considered over 300,000 properties that have been sold at least twice in the period 1995 – 2011. It estimates the % change in a properties retail value that may occur if it was to move between EPC ratings. Different estimates are created for different regions in the UK. With a substantial price difference seen between the retail values of properties in some parts of the UK compared to others, it is interesting to note that “the percentage premium commanded by properties with above-average EPC ratings is higher in regions where house price levels are low and vice versa.”

The region of interest for our analysis is that of Yorkshire and Humber with the relevant details of premium offered by higher EPC ratings given in Table 5 below.

Table 5: Estimated % change in property retail value from changes in EPC rating

Current rating	E rating improved to -			D rating to -		C rating to -
Potential rating	D rating	C rating	B rating	C rating	B rating	B rating
	2.30%	4.30%	12.90%	2.00%	10.60%	8.60%

4.2.2. Public funder's return on investment

4.2.2.1 Re-directed expenditure

4.2.2.1.1 Investment re-directed to retrofit

With targeted investment in retrofit there will be a change in the consumption of retrofit goods and services as well as a likely change in levels of energy consumption. These alterations in spending will mean that there will be less investment in other goods and services – the counterfactual (alternative) consumption scenario.

For the region in our analysis - the UK - there is currently a complicated sales tax (value added tax - VAT) regime applied to retrofit installations. Some retrofit installations see both their associated labour and materials taxed at a reduced rate of 5%, while other installations notably double or triple glazing or a more efficient boiler are taxed at the standard rate of 20% (Experian, 2015; HMRC, 2017). Our analysis sees a mix of reduced and standard rate measures installed. The modelled adjustments to retrofit investment will take account of whether the investment is in a standard or reduced rate measure.

The counterfactual of investment in retrofit is different depending on whether it is investment from public or private budgets. For our analysis we will assume that private investment in retrofit is re-directed from a conventional basket of goods and services. The tax rate of a conventional basket of goods and services in the UK has been estimated to be 16% (UHY, 2012). The public funds re-directed toward retrofit will not face the same counterfactual. We assume that the public funds were re-directed from alternative investment in public services i.e. education, health, the military etc. and that these face a zero rate of tax.

4.2.2.1.2. Investment re-directed from energy consumption

Retrofit, of course, also has the potential to reduce energy expenditure. The size of the reduction in energy spend is dependent on the type of retrofit installed, and the type of household receiving the installation. As highlighted in this analysis we will focus on the forms of retrofit that are suggested within EPCs in the UK and use the energy savings that are estimated here.

All residential energy sources in the UK – gas, electricity, heating oil and solid fuels –currently have a 5% sales tax rate applied to them (HMRC, 2017). We will, therefore, assume that any reduction in energy expenditure that results from retrofit, will mean a reduction in government VAT revenue that is 5% of this value.

Whether retrofit investment and potential energy bill savings result in a net loss or a net gain for government revenue depends on how the energy bill savings are re-directed. In our analysis we will assume that the savings are spent on the conventional basket of goods and services mentioned above, which has an estimated 16% sales tax rate.

4.2.2.2. Net employment changes

A net increase in employment could impact government revenues via increased income taxation and reduced unemployment welfare expenditure. Any increase in net employment is, however, dependent on the current level of activity within an economy. A depressed economy or one that is in recession should have capacity to boost demand and increase employment. Any economy, operating at near 'full employment' would not have as much potential for net employment gains. Additionally, whether it is economically desirable in the medium to long term to favour labour intensive employment options is a matter for debate among macroeconomists (Blyth *et al.*, 2014b).

The jobs related to investment in retrofit include those that are *directly* related to the installation, those that are indirectly related via employment with a business supplying the direct installation, and induced jobs, which arise from the additional economic activity that the investment may create (Ruth *et al.*, 2010). Our analysis considers the implementation of a retrofit programme in a single local authority (LA). The degree to which jobs would be created specifically within this LA is not however, something considered within this analysis. Instead we consider whether any jobs created were present in the wider national economy, with these jobs having the potential to return revenue to the national government and public budgets.

Assessments of the employment impact of investment in energy efficiency generally, or energy efficiency retrofit of buildings specifically, often relate to different counterfactual baselines. Some estimates consider the *gross* impact of jobs *supported* by the investment, while others estimate the *net* impact of jobs (jobs created) against the most appropriate counterfactual. Impacts on a government's fiscal balance can only be gauged via figures that reflect *net changes*, and therefore only net figures are considered in this analysis.

There is general agreement in the literature that energy efficiency activities would be typically more labour intensive than a fossil fuel energy generation counterfactual (Pollin, Heintz and Garrett-peltier, 2009; Wei, Patadia and Kammen, 2010; Cambridge Econometrics, 2015). Whether investment in energy efficiency is more labour intensive than a renewable energy counterfactual or what the *specific relative* labour intensity of energy efficient retrofit is in our analysis is complicated and contextual (Blyth *et al.*, 2014b). Here we consider the most relevant employment estimates i.e. those that consider direct, indirect and induced jobs in energy efficiency retrofit of buildings.

A report from Janssen and Staniaszek (2012) that estimates the job creation that might arise from energy retrofit instigated by the EU Energy Efficiency Directive, concludes that “policy-makers in the EU can rely on using a factor of 19 jobs for each €1 million invested in energy efficient upgrading of buildings when formulating new policies.” Alternatively, a macroeconomic modelling analysis of the economic and fiscal impacts of retrofit in the UK by Cambridge Econometrics (Washan, Stenning and Goodman, 2014) uses an estimate of roughly 11 jobs/ £1 million investment. An evidence review from the UK Energy Research Centre of the employment impacts of investment in energy efficiency and renewable energy cites two sources that consider the impacts of energy efficiency in buildings. Ruth et al (2016) estimates the direct, indirect and induced jobs from “efficiency improvements in the residential sector’s use of natural gas”. UKERC convert these estimate to be roughly 0.8 net jobs per annual GWh saved.

In our analysis we will use the study by Cambridge Econometrics and the estimate of 11 jobs per £1million invested in retrofit. This is lower than the Janssen and Staniaszek (2012) figure but due to its precise application to the UK and the period in question, it is deemed more relevant. This jobs estimate includes direct, indirect and induced jobs using ratios from the analysis of Ruth et al (2010) on an energy efficiency retrofit scheme in the USA. Although this scheme takes place in a different context, it is of a similar nature to the scheme suggested in our analysis and the disaggregation ratio is considered the best fit.

With the estimate of jobs created from investment in retrofit we use figures from a study of the fiscal impacts of investment in solid wall insulation in the UK from Rosenow et al (2014) to assess the level of additional income tax and the reductions in welfare spending that the net job creation would involve. This analysis suggests that a job created by retrofit investment generates £4,819 additional income tax per annum, and a £4,307 reduction in welfare expenditure per annum. We assume that direct, indirect and induced jobs would offer the same level of income tax to the public budget.

4.2.2.3. Public health budget savings

The health implications of occupants living in retrofitted properties is regularly valued by government in terms of the effect it has on the achievement of social policy goals e.g. fuel poverty alleviation. There is also a case for retrofit implementation to be valued in terms of the impact it might have on public health budgets – an economic rather than a social case for action. Health benefits in this sense are linked to how much public expenditure goes toward health spending. Most countries public budgets contribute to health spending to some degree, but some more than others, for example, the predominantly publically funded health care system in the UK, compared to the mainly private health care system in the USA (WHO, 2016).

The area of Kirklees is one that is well known in retrofit policy circles in the UK due to the Kirklees Warm Zone (KWZ) scheme, which took place between 2008-2010. The scheme is widely considered a success and is seen as an example of best practise for other Local Authorities. This reputation has helped to facilitate a variety of different analyses of the schemes impacts, largely focusing on the amount of energy and carbon savings that can be attributed to the scheme (Beagley *et al.*, 2011; Kirklees Council, 2011; Phil Webber, Gouldson and Kerr, 2015). One study from the University of Ulster (Liddell, Morris and Lagdon, 2011) seeks to estimate the health and well-being outcomes of the KWZ scheme. The report uses the Quality-Adjusted Life Years (QALY) metric to perform its estimates. A single QALY represents a year of an individual's life that is lived at optimum health. Any year that is lived below an optimum level i.e. with some form of medical condition, is given a lower weighting, to represent that this year was less valuable than a full QALY. With an estimate of how many additional QALYs were enabled by the project, and a monetary value attached to each QALY, an estimate of the monetary value of health and well-being can be made for the KWZ scheme. Although QALY measurements are a conventional means of assessing and comparing the value of different possible health interventions, they represent the social value of an intervention and do not offer any information on whether a policy intervention might provide a direct financial return to the investor.

An alternative report from Liddell (2008) considers the impact from a retrofit scheme on both QALY *and* “direct cost benefits to the NHS” (public health service in the UK). This report is concerned with the health impacts of Northern Ireland’s Warm Homes Scheme (NIWHS) 2000-2008, but performs its calculation using data relevant to the UK in general. It concludes with an estimate that between 23% and 42% of the cost of NIWHS could be considered to be offset by its health benefits, in terms of QALY improvements and NHS savings. The NHS savings are estimated to be much smaller than the QALY gains and are set at between 1% and 2% of the programmes costs. The 42% figure (or 42p in every £1 invested) is regularly cited as a saving to public health budget from retrofit (DOH, 2010; DCENR, 2011; Washan, Stenning and Goodman, 2014). As highlighted, however, this figure is only achieved if QALY benefits are included. As these benefits will not directly affect the balance sheet of the public funder our analysis will use the 1-2% estimate for public returns on investment.

4.2.3. Discounting future returns

It is common practise in economic analysis to apply a discount rate to returns on investment that occur in the future. Of the returns modelled in our analysis many occur instantaneously e.g. those that result from changes in employment, or from the upfront investment in retrofit, and thus have no potential of being discounted. The estimate of health budget savings is a % of overall programme spend. As the programme spend occurs instantaneously this is not envisaged as an ongoing saving and thus is not able to be discounted. It is also not feasible to apply a discount rate to the private ROI of property value change as we have not estimated when any property will be sold.

The returns that result from energy bill savings and the redirected expenditure that happens as a result of these take place over an estimated 20-year time frame. As these occur some distance into the future there is the potential for the future returns to be discounted. The energy bill savings are calculated using real term energy prices i.e. those that have the impact of inflation taken out, and thus have an element of discounting embedded. The public return that occurs from the energy bill savings being redirected toward an alternative, ‘conventional’ expenditure, is derived from the real term estimate of energy bill savings. As the estimated public return is derived from the estimated private return, discounting one would result in an inherent discounting of the other. As the appropriate level of discounting is considered to be different for private and social cost benefit analyses (Cambridge Economterics, 2015), to make the private and public cases directly comparable and to avoid the complexity outlined above, the use of a discount rates in our analysis was inappropriate. it was ultimately decided that the use of a discount rate in our analysis was inappropriate.

4.3. Results

As highlighted, financial policy support means that there is a joint contribution to the cost of retrofit from public and private budgets. The multiple benefits associated with retrofit mean that there is a joint receipt of returns on investment for the public and private investors. Below we outline 6 hypothetical scenarios for the financial policy support of retrofit. Each scenario involves a different relative level of private to public investment in retrofit. The analysis considers the eventual balance of private and public investment and ROI, in each of the scenarios.

4.3.1. Public and private investment

The scenarios envisage the use of £20 million of public money in different financial policy programmes in the local authority of Kirklees (£20 million is used as it is roughly equivalent to the funding available for the KWZ scheme). Our 6 scenarios range from a grant programme where public funds fully cover the cost of retrofit, to subsidised loan schemes, where pubic funding is used to buy-down the market interest rate, covering all or part of the cost of capital.

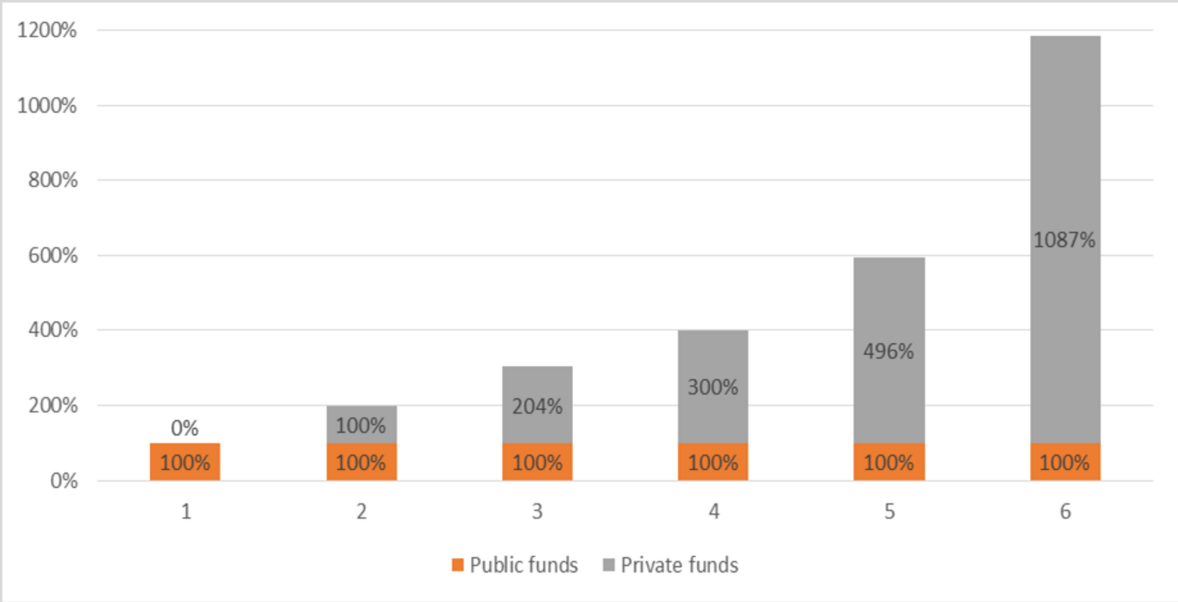
- Scenario 1 - Full cost grant: public funding used as full cost grants – covers 100% of the cost of the retrofit project - with no expectation of private funds covering any of the costs.
- Scenario 2 - Part cost grant: public funding used as 50% part cost grants, with private funds expected to cover the remaining 50% of costs.
- Scenario 3 - Full cost loan at 0% interest rate: public funding used to reduce the interest on loans to 0%, with the loan available for the full cost of available retrofit.

- Scenario 4 - Full cost loan at 2% interest rate: public funding used to reduce the interest on loans to 2%, with the recipient of the loan covering the rest of the cost of capital. The loan is used for the full cost of available retrofit.
- Scenario 4 - Full cost loan at 4% interest rate: public funding used to reduce the interest on loans to 4%, with the recipient of the loan covering the rest of the cost of capital. The loan is used for the full cost of available retrofit.
- Scenario 4 - Full cost loan at 6% interest rate: public funding used to reduce the interest on loans to 6%, with the recipient of the loan covering the rest of the cost of capital. The loan is used for the full cost of available retrofit.

Table 6: Overall costs and investment in retrofit from public and private budgets in each scenario

	Policy	Available public funds	Leveraged private funds	Overall investment in retrofit (public and private funds)	Private/public contribution	Properties retrofitted
1	Full cost grant	£20,000,000	£0	£20,000,000	0:1	3,008
2	Part cost grant		£20,000,000	£40,000,000	1:1	6,017
3	Full cost loan, 0% interest		£40,781,000	£40,781,000	2.04:1	6,136
4	Full cost loan, 2% interest		£60,048,000	£54,383,000	3:1	8,182
5	Full cost loan, 4% interest		£99,109,000	£81,575,000	4.96:1	12,274
6	Full cost loan, 6% interest		£217,372,000	£163,162,000	10.86:1	24,550

Figure 4: Leverage: relative private and public funding in the 6 scenarios



For the scenarios involving loans it is assumed that the rate of interest on loans without subsidisation is 8%. The 8% figure is roughly in line with loans of similar parameters from a recent non-subsidised retrofit loan scheme in the UK, the Green Deal (Rosenow *et al.*, 2013; UKGBC, 2014). In scenario 3 all interest is covered by the available public funds while in scenarios 4-6, part of the interest is covered by the public funds, with the rest of the cost of capital covered by the private recipient of the loan. Loans are assumed to be repaid over a period of 10 years.

Some of the assumptions in the above scenarios may not be considered wholly realistic. For example, in scenario 1 it is unlikely that no private investment would result from the use of grants for retrofit, and rather, at least some additional private investment would occur alongside the publicly funded grants. The scenarios are, however, designed only to represent varying contributions to costs between public and private budgets rather than entirely realistic funding scenarios.

In scenarios 3-6 were the interest on loans is subsidised, scenario 3 involves 30.68 rounds of investment in the sample of 200 properties (30.68 x 200 = 3,008 properties retrofit). Scenario

4 sees 40.91 rounds, 33% more. Scenario 5 sees 61.37 rounds, twice as many as scenario 3 as only half as much interest per household is being covered. Finally, Scenario 6, sees 122.75 rounds of investment, 4 times as many as scenario 3 as scenario 6 is covering only a quarter of the interest per household, that scenario 3 does. In scenarios 4-6 when public funds are used to reduce interest but not remove it completely, a portion of leveraged private funds are required to cover the non-subsidised cost of capital. Thus, in these scenarios leveraged private funds are greater than actual overall investment in retrofit.

The available public funds are assumed to come from tax revenues and not government borrowing and therefore they do not incur a cost of capital. Alternative means of government intervening to improve loan conditions include the option of guaranteeing the loans, and thus reducing the lenders risk. In our scenarios it was decided not to use this option as the analysis is primarily interested in the balance of investment to investment returns that may occur with varying contribution to costs from the private and public investors. Loan guarantees are a potentially effective means of reducing the cost of investment but as there is uncertainty around how many loans would default it is difficult to assess the ultimate investment costs from such an approach.

4.3.2. Private returns

In each of these scenarios the same 200 house retrofit sample is repeatedly invested in. In the first scenario for example this representative sample of retrofit opportunities is invested in just over 15 times. Each property in the sample has an associated energy bill saving attributed to the different retrofit measures within the EPC. All of the properties in the sample improved their EPC rating by at least one grade, with these improvements used to estimate the change in property value that would result from the retrofit.

Table 7: Private investment and returns on investment in each scenario

Scenario	Overall investment in retrofit	**Private contribution to cost**	Private return – energy bill savings	Private return – property value change	**Total private returns on investment**
1	£20,000,000	**£0**	£19,754,000	£5,535,000	**£25,289,000**
2	£40,000,000	**£20,000,000**	£39,520,000	£11,073,000	**£50,593,000**
3	£40,781,645	**£40,781,000**	£40,300,000	£11,292,000	**£51,592,000**
4	£54,383,502	**£60,048,000**	£53,741,000	£15,058,000	**£68,800,000**
5	£81,575,253	**£99,109,000**	£80,612,000	£22,587,000	**£103,200,000**
6	£163,162,469	**£217,372,000**	£161,237,000	£45,177,000	**£206,415,000**

Table 8: Cost of capital in each scenario

Scenario	Cost of capital	Cost of Capital as a % of overall investment in retrofit	Private contribution to the cost of capital	Private contribution to the cost of capital as a % of overall private contribution
1	N/A	N/A	N/A	N/A
2	N/A	N/A	N/A	N/A
3	£20,000,000	32%	£0	0.00%
4	£25,664, 000	32%	£5,664, 000	9.43%
5	£37,533, 000	32%	£17,533, 000	17.69%
6	£74,210, 000	32%	£54,210, 000	24.94%

It is assumed that the energy bill savings achieved by the retrofit occur for 20 years a figure which is line with the estimated lifespan of the retrofit measures which are implemented. The property value changes are assumed to occur when and if the property is sold.

4.3.3. Public returns

Using the retrofit investment figures outlined above we will implement the most appropriate conversion factors for the public budgetary returns from re-directed expenditure, net employment gains and health expenditure savings.

4.3.3.1. Re-directed expenditure

In the UK some retrofit goods and services are taxed at a reduced rate of 5%, while some are taxed at a standard rate of 20%. In our analysis roughly 65% of installed measures were at the reduced rate with the rest at the standard rate. For the £20million of government funding this means that £2,050,000 is automatically returned to the public budget. For our scenarios we imagine that the counterfactual use for the £20million of government funding would be expenditure on public services that did not incur any tax return to government.

Table 9: Re-directed expenditure and resultant change in tax returns from retrofit investment

Scenario	Available public funding for retrofit	Tax returned from public retrofit funding	Lost tax from counterfactual public spending (0%)	**Net direct tax return from public investment in retrofit goods and services**
1 - 6	£20,000,000	£2,050,000	0	**£2,050,000**

Private investment in retrofit involves the same ratio of reduced rate to standard rate retrofit measures as public investment. A portion of the private investment is thus received by public budgets as new tax receipts. The assumed counterfactual for the private funds invested in retrofit is a conventional basket of goods and services, which is estimated to have a 16% tax rate (UHY, 2012).

Table 10: Re-directed retrofit expenditure for each scenario

Scenario	Overall private contribution to costs	Lost tax return from conventional spend (16%)	Overall private spend on retrofit	Tax return from retrofit investment (5% or 20%)	**Net public return from investment in retrofit***
1	£0	£0	£0	£0	**£0**
2	£20,000,000	-£3,200,000	£20,000,000	£2,050,000	**£900,000**
3	£40,781,000	-£6,525,000	£20,781,000	£2,130,000	**-£2,344,000**
4	£60,048,000	-£9,607,000	£34,383,000	£3,524,000	**-£4,033,000**
5	£99,109,000	-£15,857,000	£61,575,000	£6,311,000	**-£7,496,000**
6	£217,372,000	-£34,779,000	£143,162,000	14,674,000	**-£18,055,000**

*includes direct tax return from public funding of retrofit i.e. table 9 (£2,050,000)

The private contribution to costs includes funds spent on retrofit, but also funds used to cover the cost of capital in scenario 4-6. The lost tax return from a conventional spend applies to both the funding used to pay for retrofit and that used to cover the cost of capital. The tax returned from investment in retrofit, only applies to funds spent on retrofit and not to funds used to cover the cost of capital. It is assumed that the funds spent on the cost of capital do not have a tax applied to them.

Table 11: Re-directed energy bill expenditure for each scenario

Scenario	Reduction in private energy expenditure	Lost tax from reduced energy exp. (5%)	Tax return from re-directed spend (16%)	**Net public return from energy expenditure changes**
1	£19,754,000	£987,711	£3,160,676	**£2,172,000**
2	£39,520,000	£1,976,000	£6,323,000	**£4,347,000**
3	£40,300,000	£2,015,000	£6,448,000	**£4,433,000**
4	£53,741,000	£2,687,000	£8,598,000	**£5,911,000**
5	£80,612,000	£4,030,000	£12,898,000	**£8,867,000**
6	£161,237,000	£8,061,000	£25,798,000	**£17,736,000**

In each scenario there is an estimated reduction in energy bill spending. In the UK there is 5% tax rate on fuel and power. In our analysis we assume that this reduced energy expenditure is re-directed toward the conventional basket of goods which is taxed at 16%.

Table 12: Overall re-directed expenditure for each scenario

Scenario	Net change in public returns from investment in retrofit goods and services	Net change in public returns from re-directed energy expenditure	**Net change in public returns from re-directed expenditure**
1	£0	£2,172,000	**£2,172,000**
2	£900,000	£4,347,000	**£5,247,000**
3	-£2,344,000	£4,433,000	**£2,088,000**
4	-£4,033,000	£5,911,000	**£1,878,000**
5	-£7,496,000	£8,867,000	**£1,371,000**
6	-£18,055,000	£17,736,000	**-£319,000**

4.3.3.2. Net employment changes

Using the estimate of 11 jobs *created* from £1million investment in retrofit from Washan et al (2014), the Rosenow et al (2014) estimate of additional income tax from retrofit installation jobs in the UK - £4,819 pa - and the same authors estimate of the cost of unemployment to public budgets in the UK - £4,307 - we achieve the following returns to the public budget from net changes in employment.

Table 13: Net employment changes and resultant impact on tax revenue and welfare expenditure

Scenario	Overall investment in retrofit	Net employment change	Increased income tax revenue	Reduced welfare expenditure	**Overall public budget change**
1	£20,000,000	220	£1,060,000	£947, 000	**£2,007,000**
2	£40,000,000	440	£2,120,000	£1,895, 000	**£4,015,000**
3	£40,781,000	449	£2,163,000	£1,933, 000	**£4,097,000**

4	£54,383,000	598	£2,881, 000	£2,575,000	**£5,457,000**
5	£81,575,000	897	£4,322, 000	£3,863,000	**£8,186,000**
6	£163,162,000	1795	£8,650, 000	£7,731,000	**£16,381,000**

4.3.3.3. Public health budget impacts

As highlighted there are potentially significant Quality of Life benefits from energy efficient retrofit, with the health case for retrofit frequently made in these terms. In this analysis however, we are only interested in the direct financial return on investment case for retrofit. Using the estimate of 1-2% (assuming 1.5%) of programme cost saving for public health budgets from Liddell (2008) then the scenarios could be forecast to save the following amounts for public health budgets.

Table 14: Public health budget savings from investment in retrofit

Scenario	Overall investment in retrofit	**Public health budget saving**
1	£20,000,000	**£300,000**
2	£40,000,000	**£600,000**
3	£40,781,000	**£611,000**
4	£54,383,000	**£815,000**
5	£81,575,000	**£1,223,000**
6	£163,162,000	**£2,447,000**

4.3.4. Overall balance of public and private direct, financial costs and benefits

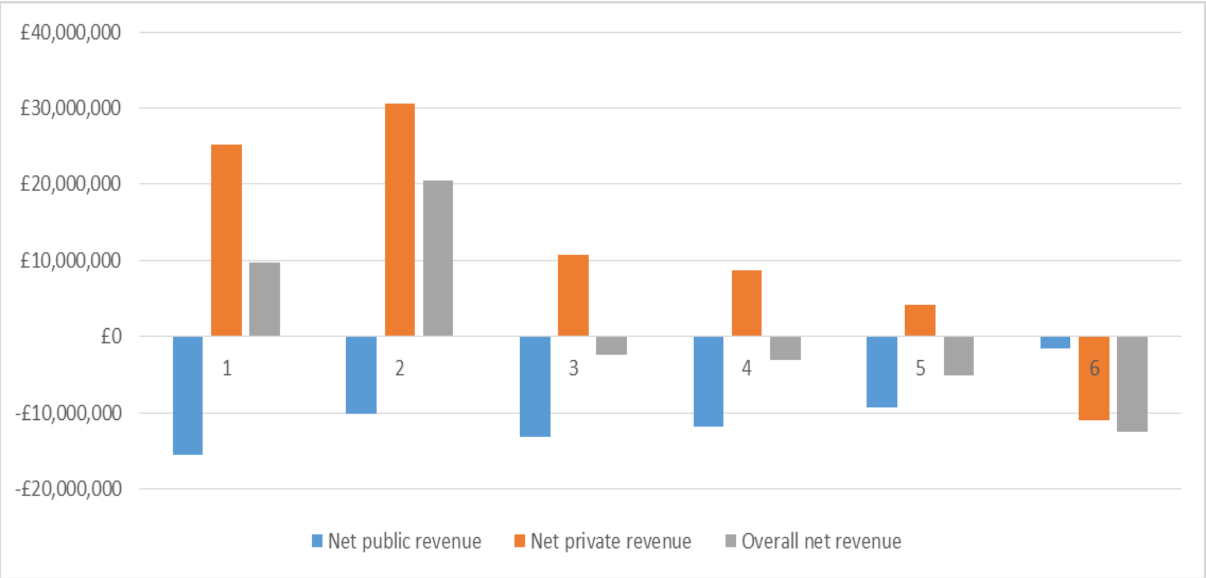
Table 15: Overall public investment and returns on investment

Scenario	Overall public investment	Net return from re-directed expenditure	Net return from employment changes	Net return from health budget savings	**Net public budget change**	Net balance of public investment and returns
1	£20,000, 000	£2,172,000	£2,007,000	£300,000	**£4,480, 000**	£15,519,315 loss
2		£5,247,000	£4,015,000	£600,000	**£9,862, 000**	£10,137,000 loss
3		£2,088,000	£4,097,000	£611, 000	**£6,797, 000**	£13,202,000 loss
4		£1,878,000	£5,457,000	£815,000	**£8,151, 000**	£11,848,000 loss
5		£1,371,000	£8,186,000	£1,223,000	**£10,781,000**	£9,218, 000 loss
6		£319,327 loss	£16,381,000	£2,447,000	**£18,509,000**	£1,490, 000 loss

Table 16: Overall balance of public and private investment and returns on investment

Scenario	Balance of public investment and returns	Balance of private investment and returns	Overall balance of public and private investment and returns
1	£15,519,000 loss	£25,289,000	£9,769,000
2	£10,137,000 loss	£30,593,000	£20,456,000
3	£13,202,000 loss	£10,810,000	£2,391,000 loss
4	£11,848,000 loss	£8,751,000	£3,096,000 loss
5	£9,218,000 loss	£4,091,000	£5,127,000 loss
6	£1,490,000 loss	£10,957,000 loss	£12,447,000 loss

Figure 5: Public and private investment in retrofit: net revenues



4.4. Discussion

4.4.1. Private returns

5 of the 6 scenarios see a net positive investment case in retrofit for private funders. The sources of private return – energy bill savings and property value change – increase the more that is invested in retrofit (see Table 7), but after substantial net profits in scenarios 1 and 2, overall profits decline as proportionally more private funds are invested in retrofit and used to cover the cost of borrowing.

In scenario 1 when there is just public and *no private investment* in retrofit, private budgets make a profit. In scenario 2 when an equal amount of private and public funds are invested, the private returns double, and there is an even greater net profit for private budgets. In scenario 3 when the public funds are used to cover the cost of capital and actual investment in retrofit comes solely from private funds, the net investment case for private budgets begins to worsen. The contribution to the costs of borrowing is shared by public and private funds in scenario 4-6. As the relative proportion of this that is covered by private funds increases, private profits eventually turn to losses by scenario 6.

As can be seen in Table 7, in our case study there is a profitable investment case for private funds in retrofit, without the use of public subsidy. The returns from energy bill savings are slightly lower than the overall private investment, but the return from property value changes pushes the investment into profitability – the property value increase in our case study accounts for roughly 28% of the cost of retrofit. This profitability is gradually reduced in scenarios 3-6 as loan mechanisms are used, and some public and private funds are required to cover the cost of capital. As can be seen in Table 8 the cost of capital makes up about 32% of the overall required investment in scenarios 3-6. As the proportion of this that is required to be covered by private budgets increases, proportionally more of the overall private investment is used to cover the cost of capital.

These results help to demonstrate the importance of the cost of borrowing in retrofit support mechanisms. Our results demonstrate an investment case where profit-making can be turned to losses if the overall cost of investment in retrofit includes too much of a cost from borrowing. There are some examples of a commercial rate of interest on a loan being unappealing to households potentially interested in borrowing for retrofit (Marchand, Lenny Koh and Morris, 2015; Rosenow and Eyre, 2016). Households considering energy efficiency investments are likely to implicitly apply high short term discount rates (Wilson and Dowlatabadi, 2007). Policy interventions looking to encourage private investment in retrofit, therefore, may need to ensure that there is a better than marginal investment case for retrofit, with one means of doing this lessening the cost of borrowing.

4.4.2. Public returns

In each of our 6 scenarios there is a net loss for public budgets – these findings are similar to those of previous analyses (Rosenow, Platt and Demurtas, 2014). The overall investment case for public budgets, however, improves as more private investment is leveraged. This is primarily because of the increases in public returns that occur from changes in net employment (see Table 15). These returns come from increased income tax and lower welfare expenditure, and work out as about 10% of the overall (public and private) investment in retrofit, in each scenario. The public return on investment from health savings is estimated as a fixed % (1.5%) of overall investment in retrofit and thus also increases as more private funding is leveraged.

The public returns on investment from re-directed expenditure are more complicated. There are two possible ROI streams from redirected expenditure; funding redirected *into* retrofit, and funding redirected *from* energy expenditure.

Both private and public funds that are re-directed into retrofit incur a tax rate that then goes to public budgets. Although this tax rate is the same regardless of whether public or private funds are invested, the counterfactual is different for private funds than it is for public funds. The counterfactual for public funds is assumed to be investment in other public services, and is assumed to incur no taxation. The public ROI from public funds being redirected into retrofit is therefore positive, and as the amount of public funding is fixed, this ROI is fixed (see Table 9).

The public returns that result from redirected private expenditure are negative, because the counterfactual for this expenditure has a higher rate of taxation i.e. 16%, than the tax on investment in retrofit. The assumed rate of tax for investment in retrofit depends on the type of retrofit invested in (see section 2.2.1), some are at a reduced rate of 5% and some at a standard rate of 20%. In our analysis, with 65% assumed to be at the reduced rate, the de-facto tax rate works out as 10.25%; lower than the assumed 16% rate on the counterfactual. The modelled negative public return from private expenditure redirected into retrofit would be positive if all retrofit was at the standard rate of tax (20%). Such a change would, however, increase the cost of retrofit for households and potentially act to reduce overall private investment in retrofit, lowering public returns from net employment gains and health budget savings.

The other redirected funding stream is that of energy expenditure. The UK has a relatively low level of sales tax on energy when compared to other European countries (Vaasa ETT, 2017). If its sales tax was at the standard rate i.e. 20%, or if it was at a level similar to that of most other European countries, there would be a loss in tax receipts from reducing energy expenditure. As the tax on energy in the UK is 5%, redirecting expenditure to the conventional basket of goods and a 16% rate, results in a positive return for public budgets (see Table 11). In every scenario except scenario 6, these returns are higher than the losses incurred from the redirecting of investment toward retrofit, and thus in 5 of the 6 scenarios redirected expenditure results in a net gain for public budgets (see Table 12).

Overall, each of the three potential revenue streams– re-directed expenditure, employment creation and health budget savings – normally offer a positive return to public budgets - with the exception of redirected expenditure in scenario 6. When these revenue streams are combined however, in none of our scenarios are they able to cover the public investment in retrofit.

4.4.3. Overall observations

The reasons for retrofit are many and varied, with the economic case for both public and private actors only forming a part of the overall rationale. It is however, regularly observed that there are both private (Enkvist, Nauclér and Rosander, 2007; Kesicki, 2010) and public (IEA, 2014a; Washan, Stenning and Goodman, 2014) economic returns on investment from retrofit. Whether retrofit investment is ultimately profitable for either party is dependent on the specifics of the investment made. In this case study private investment in retrofit was profitable in the absence of public subsidy, as long as there was no requirement to cover the cost of capital invested. Public subsidy will, of course, aid the private investment case but ultimately if too much private funding is required to cover the cost of capital, even with public subsidy the private case may lose profitability altogether.

The leveraging of private investment in retrofit with the use of public funding and policy programmes more generally is desired by many public funders of retrofit around the world. Our analysis compares the investment case of the private and public funders and finds that in this particular case study, whenever public and private funds are solely invested in retrofit, and there is no need to cover any additional costs i.e. borrowing costs, there is a much stronger investment case for the private funder than there is for the public funder. It is important to note however, that there are returns on investment for the public funder. These returns mean that any investment in retrofit, private and/or public, will provide a revenue stream for public budgets. Any private investment in retrofit, therefore, not only helps public funders to more cost effectively and equitably achieve their retrofit investment targets, but it also provides an economic return. This return on investment case for the public funder is something that has been observed in other analyses although to differing degrees (Kuckshinrichs, Kronenberg and Hansen, 2010; Rosenow, Platt and Demurtas, 2014; Washan, Stenning and Goodman, 2014).

Our analysis modelled different relative levels of leverage of private funds with public subsidy, from no private investment, to nearly 11 times more private investment than public (see Figure 4). A useful comparator for these ratios is the KfW loan system in Germany - a scheme that is considered a leading example of good retrofit policy (Murphy, Meijer and Visscher, 2011) and one that is envied by other countries in terms of its levels of private to public contribution (Guardian, 2012). It is estimated that in one particular year for every €1 of public subsidy, €4 euros of private funds was leveraged (Rosenow, Platt and Demurtas, 2014). This level of leverage is comparable to that in scenario 5 in this analysis.

As highlighted attempts to move from retrofit scenarios with high levels of public subsidy to those with a greater private contribution to costs have so far proved difficult. Despite the cherry-picking prioritisation of the most cost-effective measures (Galvin, 2010; Sweatman and Managan, 2010), the private economic case remains a potentially influential rationale for encouraging households to retrofit. This positive investment case is potentially removed if too much funding is required to cover the cost of borrowing the capital needed for investment. The extent to which any future funding for retrofit – public or private – has to cover the cost of borrowing is therefore potentially critical when seeking to attract private investment. Our hypothetical funding model saw scenarios with lower levels of investment i.e. scenarios 1 and 2, that did not require any borrowing and scenarios with higher levels of investment that did. Alternative funding models where the cost of borrowing is reduced either by government loan guarantees or via alternative sources of funds – green investment banks, revolving energy efficiency funds (Gouldson *et al.*, 2015; Canes, 2016) – could offer useful alternatives to the public subsidisation of the cost of borrowing. As is demonstrated in scenario 2 a system where there is both public and private funding of retrofit and no cost of borrowing offers the greatest overall return on investment case for retrofit.

The potential levels of vertical cross subsidisation of public policy objectives by private households is outlined in the scenarios above. This analysis does not seek to determine what an appropriate level of public and private contribution to the costs of retrofit might be, but only to inform the issue by considering the balance of economic costs and benefits in different hypothetical scenarios. How secure, low-carbon energy is provided in the future is an on-going and complex policy question. Demand reduction sits alongside low carbon supply as one of the two key options for future energy systems. The funding of low carbon energy systems can come from a variety of sources, such as centrally collected tax, hypothecated tax or private sources. Due to the heterogeneous application of retrofit to some homes and not others, compared to the potentially universal application of other energy system transition options i.e. low carbon electricity or some low carbon heat systems, there are particular distributional implications from retrofit. Public subsidy can lead to considerable private economic and non-economic benefit for some homes but not others, with these distributions having the potential to be politically damaging to low carbon transitions efforts. Investment in retrofit from the private recipients of retrofit is therefore desirable to government as it can help to address policy objectives but also because it lessens politically difficult issues of distribution.

The level of public sector cross subsidisation or when one public account bears the costs and another account benefits, is relatively limited in our case study. Public health budgets receive a small saving from investment that may come from central funding sources or from a levy on all energy consumers. Public sector cross-subsidisation is more likely to occur via non-economic benefits, as highlighted the health benefits of retrofit tend to predominantly occur in terms of Quality of Life rather than actual budgetary savings.

The fiscal implications of government policy are an important consideration for policy makers, but their modelling is distinctly complex. The returns to public budgets modelled here all come with relevant caveats. The redirected expenditure findings result from the particular tax levels found in the case study. As highlighted tax rates on energy in the UK are low by European standards, and thus an analysis that considers expenditure redirected from energy bills in another country may result in a loss for public budgets. The net employment estimates used may be considered conservative in comparison to some other estimates (Janssen and Staniaszek, 2012), but given that the rate of employment creation is considered to be contingent on the general state of the economy and the relative counterfactual, a more conservative estimate was considered appropriate. The net impact to public budgets from the health benefits is also difficult to estimate. It can be argued, for example, that the increased life expectancy of someone living in a warmer home “could be translated into an increase in healthcare later in life” (Alexandri *et al.*, 2016).

4.5. Conclusion

This paper carried out a comparative assessment of the economic return on investment case in energy efficient retrofit for public and private budgets. The analysis seeks to add to the literature on both the public case for retrofit policy support and the private household case for retrofit investment. It also intends to contribute to the debate on the future of retrofit funding in the UK.

This analysis builds on existing work that has considered the public return on investment case for retrofit. It is distinct, however, by offering the first comparison of the public and private investment cases. It is also the first in the UK to compare the overall level of economic benefit from property value change to the upfront investment in retrofit. It shows that alongside addressing social policy objectives like carbon emissions reduction and fuel poverty there is an additional economic rationale for public investment in retrofit. In our case study the public economic case is not positive unless there is a substantial level of private funding leveraged by the available public funds.

The private household economic case for investment in retrofit combines returns from reduced energy bill expenditure and improved property value. If private investment is made without any need to pay for the cost of capital, private households face a profitable economic case. If there is a cost of borrowing then this profitability may disappear. With the rationality of 'homo economicus' long in doubt the economic argument for investment in retrofit has to some degree been overplayed. Debates around the equity of energy system transition are however critical, and in this analysis we outline the shared contribution to costs and the shared receipt of benefits that can occur. We seek to draw attention to these and to the implications they might have for the relationship between public administrators and private citizens.

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5. Discussion

5.1. Thesis overview

The research in this thesis relates to the political, social and economic aspects of the energy efficient retrofit of existing residential buildings. The thesis is guided by the research question - why are the relevant actors – government (macro level) and households (micro level) – interested (or not) in engaging in home energy efficiency retrofit activity – what is their rationale for retrofit?

It was motivated by some of the key features of the broader low-carbon energy system transition. Principle among these is the developing benefit framings, of climate change mitigation with 'co-benefits', and energy efficiency with 'multiple benefits'. What effect do these framings have on their intended audience and what might the implications of recognition be. Secondly, the research is inspired by the existence of contrasting perspectives on the most appropriate means of framing climate action. Whilst some research emphasises the economic impacts of climate mitigation other analyses claim that the scale of change required to address climate change will not be adequately addressed with an economic focus. Different viewpoints that in theory want the same thing (climate mitigation) but have different perspectives on how this shared ultimate goal should be achieved. Thirdly, the conflicting perspectives and perception of multiple benefits help to give rise to research that pursues an interdisciplinary perspective. Interdisciplinarity is considered a fundamental part of energy sector research and with respect to modern, complex, joined-up problems such as climate change. Finally, the research is drawn to the topic of home energy efficient retrofit by its perceived relative level of technological and economic advantage over other low carbon options and by its application to a broad range of citizens. If a low carbon society is to be achieved, then a comprehensive perspective on what can be achieved by home energy retrofit is a fitting prerequisite.

The following sections consider the contributions, limitations and opportunities for further research that relate to each of the chapters of the thesis.

5.2. Macro-level analysis: the rationale for retrofit policy

The background literature sets out that energy efficiency and energy efficiency retrofit have been framed as having multiple benefits. This framing emerges from an advocacy coalition of actors that come from a wide variety of institutions and positions i.e. inter and non-governmental organisations, charities, retrofit goods and services firms, academics etc. (see introduction chapter 1.2.4.1), that coalesce via a shared belief in the value of retrofit and act with a non-trivial level of cooperation (Sabatier and Jenkins-Smith, 1999). The promotion of EE as having multiple benefits can in part be seen as a reaction to the perceived historical undervaluing of EE, and as reflective of a belief in its importance within energy system transition plans (IEA, 2014a). EE retrofit policy has existed in a number of countries around the world for a number of years indicating a recognition of some of its benefits at the macro level. Whether adoption of a “multiple benefits approach to policy-making” (IEA, 2014a) would therefore result in ‘incremental’ policy change – an evolution rather than a revolution (Lindblom, 1979) or be an example of punctuated equilibrium (True, Jones and Baumgartner, 1999) would need a more thorough analysis of all forms of policy related to retrofit. Retrofit policy does appear to be subject to a Downesian issue-attention cycle that is associated with environmental policy, with funding gradually falling from intermediate peaks in each case study.

Chapter 2 sets out to assess the extent to which a selection of national governments have, in recent history, recognised (valued) the perceived benefits of retrofit in the rationale for retrofit policy. The rationale used by government for a particular form of policy cannot be objectively measured; it has the potential to shift over time and will vary between the multiple actors involved with policy-making. There are distinct limitations to the association of causes with effects in macro policy-making environments (Lawson, 1997; Pawson, 2006). In line with the critical realist perspective on social scientific research the accounts of policy rationale provide ‘momentary’ or ‘partial’ truths of government attitudes to retrofit (Pawson, 2013a). The dynamic aspect of a policy’s rationale are to some extent captured in the research by the consideration of how an agenda is *shaped* (changes) over time (Tallberg, 2003).

This research entailed the assessment of a variety of sources of evidence. The existence of policy impact assessments in each country allowed for an initial reporting of the formally stated, quantified and non-quantified benefits of policy. This reporting was complimented by additional government and non-government literature that related to the objectives of the policy as revealed by its design and outcomes. Finally, these sources were joined by evidence from the opinions of relevant policy experts in each policy context, via semi-structured interviews. From these sources of evidence narrative descriptions of the policy rationale in each case study were developed. Despite the aforementioned limitations, the ‘big picture’ narratives do reveal some marked differences between the four contexts.

By setting out the research questions identified in the introduction chapter the research pursued a somewhat deductive approach. In this section, additional observations are offered on the research questions, as well as some subsequent observations that arise from an abductive approach to reasoning that seeks some possible explanations for the gathered data.

The benefits of retrofit that were considered here can all be interpreted as examples of market failure, public goods or social policy, all of which can be used as explanatory mechanisms for policy intervention. As highlighted in the literature review, climate change can be interpreted as market failure, while climate change mitigation (carbon emission reduction) can be interpreted as the provision of a public good. Fuel poverty, and the perceived health benefits of retrofit, are most appropriately viewed as an example of the morally-driven policy of redistribution, and thus as social policy. Unemployment is considered to result from inherent features of a labour market such as geographical immobility but also features that can be conceived of as ‘market failures’ such as imperfect information. It has also been suggested that energy security has some of the characteristics of a public good (Szalbierz and Ropuszyńska-Surma, 2017). UK policy IAs list a number of market failures that retrofit is associated with addressing i.e. a lack of information, access to capital and negative externalities. (DECC, 2012b).

The background literature demonstrates that the interpretation of concepts like public good and market failures is highly subjective and that although still widely used in formal descriptions of UK retrofit policy rationale, they should be seen as a decidedly myopic means of interpreting government rationale. The lens of multiple streams theory enhances our understanding of policy formation by outlining that the identification of policy problems (even via flawed mechanisms such as market failure) is not sufficient to lead to policy formation. Policy problems need to align with an appropriate policy solution and sufficient political will, before a policy window of opportunity might open. It is not correct to conceive of policy formation as a linear, rational process of problem recognition followed by solution identification.

The macro-level analysis set out to consider “the extent to which the same policy solution can be associated with multiple policy problems”. The theoretical framing of a single policy solution stream converging with multiple distinct problem streams (the essence of the macro-level multiple benefit framing) is not one that was regularly encountered in the reviewed literature. The closest example came from Kingdon's original text in which the author suggests National Health Insurance in the USA as an example of a solution that can address a number of problems. All of these, however, are "problems in the health care system" i.e. "gaps in private insurance coverage, lowered access to medical care for those who have inadequate coverage, heavy financial burden on some" (J. Kingdon, 1995). The example of retrofit is arguably much more theoretically distinct as it entails a policy solution that is associated with policy problems from a number of different political domains i.e. health, environment, and employment.

From the research findings we can, to an extent, recognise the emphasising or de-emphasising of different benefits over time and consider how retrofit's place on the agenda was structured. In the UK, it was felt that recognition of the carbon benefit aligned with large increases in public funding circa 2008, but that the influence of fuel poverty helped to maintain it at a high level. Interestingly the influence of fuel poverty then arguably worked to undermine the rationale for retrofit in the UK due to the way the policy was funded i.e. via energy bills. This example demonstrates multiple problem streams (benefits) working together to support policy but then being undermined by the politics stream and the design of the policy.

Germany saw the most temperamental level of public funding, rising and falling several times. The fluctuations in funding are associated with the way retrofit funding receives annual scrutiny in Germany, in another example of the influence of the politics stream on ultimate policy outcomes. The increase to the higher levels is associated with recognition of the carbon benefit combined with an acceptance of retrofit's employment and economic benefits. The findings from New Zealand suggest that the connection of the jobs benefit with the previously recognised health benefits helped to boost public funding for retrofit. The research uncovered a deeply political process in NZ that involved party political collaboration for this change to occur. The jobs benefit was associated with a similar impact in Ireland where the carbon and fuel poverty benefits were already recognised, but in a country deeply affected by the financial crisis and economic recession post 2008, the economic argument of job creation helped to grow public funding. These examples all highlight the importance of the political stream in the development of policy.

The findings also show that rather than a straightforward cumulative effect, recognition of the perceived multiple benefits of retrofit are more appropriately characterised as having different relevance, at different times, to different audiences. The temporal variability of benefit recognition is most apparent with respect to the employment/fiscal benefit, which appears more transient, gaining salience at focussing events such as economic recession. Such variable recognition is in keeping with the evidence that the job creation potential of retrofit is dependent on contextual levels of economic activity (Blyth *et al.*, 2014a) The social benefits of climate change, fuel poverty and health benefits have a more long-term, chronic influence on policy rationale, although attention can be focussed toward some during the colder winter months.

It may be the case that diversity of benefits, helps to keep retrofit on the political agenda over time. A “diversity of groups in civil society” are recognised in climate policy as necessary to help “continue to press and keep necessary reforms and innovations going” (Giddens, 2009). Whether it is more appropriate to label retrofit framing as involving multiple benefits or as being a climate policy with co-benefits would require a wider set of case studies. While NZ is the only country in our research where carbon was not front and centre of the rationale, it should be recognised that the use of ‘benefits’ language in this area is “still fluid” (Fawcett and Killip, 2017). Generally, but not always (see chapter 4), the evidence related to the benefits of retrofit suggest that all retrofit will result in some amount of each benefit i.e. some energy savings will occur – reducing carbon, improving energy security – warmth will be easier to achieve – improving health, reducing fuel poverty – and all retrofit will require employment. Thus, there is an advocacy dynamic which may entail proponents that are focused on a particular benefit seeking to promote retrofit via benefits which are not their primary concern. For example, a fuel poverty charity advocating retrofit in terms of its perceived impact on employment.

Although the separation of economic and social policy may be slightly “crude” (Alesina and Rodrik, 1994) it is used here to help characterise the overall rationale for retrofit policy. A common adage of policy studies is that “policies determine politics” (Lowi, 1972) – based the observation that some forms of policy need central control (environmental) while some can be more de-centralised (social). Whilst with respect to policy IAs, Radaelli (2005) asserts that “if more than one logic is at work … it is easier to account for different results.” It seems sensible, therefore, to consider the possibility that different rationales may result in different policy outcomes.

There is the possibility that recognition of a more economic rationale, which is interpreted as offering a return on public funding investment, may be more amenable to political decision-makers with limited funds. This theory is abducted from observing the relatively high levels of funding in Germany, which had the most ostensibly economic rationale, compared to the relatively low levels in NZ which had the most consistently social rationale. It should also be noted that the level of public funding for retrofit in Ireland and NZ rose to their highest levels at the point of heightened recognition of the employment benefit. Any possibility that the advocates of retrofit may gain greater traction from an emphasis on economic benefits, is complicated by the seemingly temporary salience that this benefit entails. The perception of a dominant techno-economic perspective in energy policy making (Lutzenhiser, 2014; Cooper, 2017) may also help to explain the influence of the more tangible, quantifiable benefits of economic returns, if only at certain times and certain contexts. Generally, however, whilst it is impractical to try and distinguish the precise level of economic and social influence on the overall rationale for policy, retrofit is probably most regularly associated with social, distributional effects than it is with economic ones.

Another interesting dynamic of the benefit coalition around retrofit is the extent to which policy problems complement each other, or whether there may be occasions when they can conflict. There is a recognised tension between retrofit's ability to reduce carbon emissions and the extent to which it addresses fuel poverty and improves public health. For those not living in sufficiently warm homes retrofit may not act to reduce energy use and thus carbon emissions, but instead allow a higher level of warmth with the same level of energy use. The promotion of retrofit as a means of addressing fuel poverty may therefore undermine the ability to promote retrofit as a means of reducing carbon. Although not encountered in this research there may also be a tension between retrofit's environmental credentials and its association with increased economic activity. In certain political contexts, environmental and climate policies can find cross-party political support hard to find e.g. New Zealand, while there are also those that are unmoved by the concept of fuel poverty e.g. Germany, or the ability of certain forms of investment to be attributed with job 'creation' e.g. the UK. The framing of retrofit by its proponents, therefore, needs careful calculation with respect to which message is delivered to which audience.

It is also important to think about the association of cause and effect, or the causal story with respect to each of the policy problems i.e. the extent to which they are associated with retrofit or with other causes (Stone, 1989). Retrofit has been intrinsically associated with an opportunity to reduce carbon emissions but this association may change as the easiest most cost-effective retrofit measures dry up. The link between fuel poverty and energy inefficient homes is one that is frequently made. It is not, however, the only associated cause of fuel poverty, with some authors suggesting that retrofit can distract from other causes like the nature of the energy market, and broader social issues (Middlemiss, 2016).

The ‘chicken and egg’ question of ‘consequential’ or ‘doctrinal’ coupling and which came first, the problem or the solution, is to an extent moot (Zahariadis, 1999). What is ultimately important is that they are synergistic. The retrofit policy solution could, however, be interpreted as something which existed in a ‘pool’ of policy solutions, from an indeterminate point in time and which has connected with various policy problems, via the successful promotion of advocacy groups, in recent years. The emphasising and de-emphasising of the benefits over time, with some form of retrofit remaining in place, does place the issue somewhat in the camp of doctrinal coupling.

In conversation with policy studies experts it has been suggested that instead of interpreting the multiple benefits of retrofit as distinctive problem streams they could alternatively be conceptualised as simply altering the *framing* of a policy solution and changing the policy’s ‘image’. The concept of policy ‘image’ was devised by Baumgartner and Jones (Baumgartner and Jones, 1991) and relates to the idea that the public and/or elite understanding (image) of a policy problem may change over time or may be viewed differently in different institutional venues. They use the example of civilian nuclear policy in the USA, which has been viewed positively as an “abundant source of electricity” or negatively via the “destruction associated with nuclear war”. The research in this thesis differs, however, as it refers to the image of a policy solution rather than the policy problem example used by Baumgartner and Jones. As highlighted, the problems that are associated with the solution are also all from distinct domains of policy.

This research draws attention to the potential for governments to implement the same form of policy but for different reasons. As highlighted, a multiple benefit framing has been applied to other forms of policy and is arguably connected to a NPK mode of scientific research production. In an increasingly joined-up and interconnected world there is the potential for many more areas of government policy to be framed in terms of their potential wide-ranging impacts. The ultimate rationales for government policy and the impact that rationales have on policy development and stability may have the potential to be a significant research topic. There is also the issue, not addressed in this research of policy evaluation. If there are multiple expected outcomes from a policy then it becomes more difficult to evaluate whether a policy has or has not been effective (Blum et al., 2013).

Although retrofit policy is most commonly associated with carbon emission reduction policy it is probably unfair to say that retrofit is a carbon policy with co-benefits. At times retrofit policy has been justified predominantly on the basis of its perceived impacts on fuel poverty (Ireland) and on public health impacts (New Zealand).

5.3. Micro-level analysis: narrative experience of household renovation

A multiple benefit framing of EE retrofit is applied to households as well as governments. Both stakeholders face a variety of different reasons for retrofit and although some of the perceived benefits may be difficult to distinguish as specifically macro or micro, overall there is a distinctive multiple benefit case for households that is different to that of governments.

The behavioural research literature that relates to retrofit at the micro level is focused on the broader rationale for retrofit – the reasons for and against, rather than just what the multiple benefits of retrofit might be. On the basis of this literature, the micro-level research in this thesis entails a different perspective of the rationale for retrofit than is taken in the macro-level research.

The micro-level research considered broader home renovations rather than just retrofit, due to the view that most households do not typically discern between these activities (Gram-Hanssen, 2014a; Wilson, Crane and Chryssochoidis, 2015). By using Q-methodology, the research sought to develop a more holistic perspective on household behaviour than the drivers and barriers perspective that is conventionally employed. A comprehensive set of statements relating to the many proximate and ultimate influences on household renovation behaviour was initially gathered from 40 recorded semi-structured interviews. Using this data a concourse of statements was developed under the framing of “the conditions of daily life, expectations of consequence and personal values that influence the act of home renovations”. The research sought to be better situated within the conditions of daily life that are thought to ultimately lead to home renovation. The study set out to address the issue of the heterogeneity of households by developing narratives of the household experience that could be used to better understand household behaviour and would have a variety of applications. These narratives were developed via the cross-correlation of Q-sorts from a purposively selected group of households and subsequent abduction reasoning.

Q-methodology was chosen due to its association with capturing holistic perspectives and the research’s focus on multiple benefits/influences. The research was guided by recent articles from the interdisciplinary Energy Research & Social Science journal. The existing applied behavioural research on retrofit was subject to critical comparison with a sociological perspectives from Wilson et al (2015), whilst Kastner and Stern (2015) systematically reviewed the literature on the multiple influences related to decision making and energy investments. The research in this thesis was built on observations from these articles in particular as well as the wider literature.

The micro-level research is arguably the most directly applied work in this thesis. It is associated with the multiple calls in the literature for a more heterogeneous understanding of households. The four narratives do not account for all household experiences of renovation. They should, however, depict substantive, recognisable descriptions of a portion of the renovating population. In accordance with the critical realist philosophy, interpretation of these narratives should refer to the context from which they came. Both the concourse of statements and the eventual Q-sorts were collected from households in the North of England, which were predominantly located in urban areas. As highlighted in chapter 3 it is probably not necessary to design policy programmes specifically for each particular renovation narrative. It would be more pertinent to ensure that developed policy programmes were relevant to the experiences and conditions of daily life of the existing narratives.

The following section considers some potential policy applications from the narratives developed in the research. The 'Organised and seeking greater comfort' narrative involves larger, more pre-meditated projects that entail minimal amounts of energy renovation. The scale and organised nature of the renovation indicate that these households have the resources to engage in energy renovation but choose not to. Regulation that mandates energy renovations when other renovations take place has existed in German, Danish and Swedish regulations for a number of years, but has proven politically difficult in the UK (HOC, 2013; Mallaburn and Eyre, 2013). If these 'consequential improvement' regulations applied only to more premeditated, larger renovation projects such as those carried out by narrative 1, as opposed to more minor, reactive work like that carried out by narrative 3, they could be more politically acceptable.

Narrative two, 'Settled and performing a functional upgrade', have similar organised and proactive characteristics to narrative one, but differ due to their greater focus on energy renovation. As this narrative is already involved in some retrofit, encouraging them to retrofit further would mean that they were potentially engaged in 'deeper', more technically challenging and expensive renovation projects. The KfW loan scheme in Germany is a policy model that is associated with 'deeper' renovation projects and relatively high levels of private to public funding (Rosenow *et al.*, 2013; Rosenow, Platt and Demurtas, 2014). Government funding support that requires a lower contribution from the private recipient i.e. potentially grants or tax reduction incentives, would ideally target those currently uncommitted or that do not have the financial means to retrofit. Low cost financing may provide a more suitable means of encouraging already committed retrofitters like narrative two to carry out further, deeper retrofit.

There are a variety of avenues for the offer of retrofit finance. Many home-owners have established relationships with a bank through an existing or concluded mortgage arrangement. It is suggested that these existing relationships could provide the best opportunity for the offer of 'green finance'. It is argued that more detailed energy cost estimates that better account for a home's energy performance should give rise to favourable mortgage conditions that take account of a household's lower energy bills, and therefore lower overall outgoings. The offer of a 'green mortgage' could be made to those considering energy renovations on their property (Hamilton, Huebner and Griffiths, 2016). Additionally government could intervene to either underwrite, or subsidise the interest on these loans in order to offer even more preferential terms. Deeper retrofit can be further encouraged with performance-based incentives i.e. loan conditions that improve as the level of energy performance improves, as seen with KfW loans in Germany (Galvin, 2012).

Narrative three can be characterised as carrying out essential renovations, with limited time and planning. As the household most likely to be unsure of what the best options are, and to have the least time to research options, information programmes on what energy renovations are possible when changing the layout of a home, could be useful. The effectiveness of information schemes with respect to changing behaviour is, however, considered by several sources to be distinctly limited (Gram-Hanssen *et al.*, 2007; Wilson and Dowlatabadi, 2007; Murphy, Meijer and Visscher, 2012). Information should be simple, salient and easily accessible and is most influential at the planning stage rather than at the point of getting interested (Wilson, Chryssochoidis and Pettifor, 2013). It is also important to properly consider the points and sources from which households might receive information. Renovation installation and retail intermediaries are considered a critical source of information (Owen, Mitchell and Gouldson, 2014) while face-to-face information is generally considered more valuable (but more expensive) than Energy Performance Certificates (EPCs) (Murphy, 2014). EPCs describe the current energy performance of a building and how this performance could be improved. These information points could be improved via better engagement with the aforementioned intermediaries, and by the inclusion of advice on how and when energy measures can be integrated into amenity renovations (Christensen *et al.*, 2014). Examples of this form of practise can be seen with Building Renovation Passports as trialled in some European countries (Fabbri, Groote and Rapf, 2016).

There is the potential and the desire for a lot of work in narrative 4, but they the lack resources to be able to do it. Government funding support that requires less contribution from the private recipient would obviously be of benefit but due to the scale of possible retrofit opportunities, austere government budgets and concerns around equitable distribution, fully funded retrofit support may have limited potential. With the likelihood for leveraging a greater private contribution, loan schemes can be seen as a preferable policy mechanism for government finances (Curtin, 2014). The design of such schemes is, however, of huge importance. Poorly designed schemes, such as the Green Deal in the UK (Pettifor, Wilson and Chryssochoidis, 2015; Rosenow and Eyre, 2016), can lead to wasted public money and policy mechanisms with a bruised reputation. Policy makers looking to target this narrative could consider incentive schemes that provide for both energy and amenity renovations simultaneously. Tax relief (income, property or VAT) for households carrying out solely amenity renovations is seen in some countries already, for example the Home Renovation Incentive in Ireland (Ricardo-AEA, 2015). If such schemes required some aspect of energy renovation to take place alongside any other renovation it could make retrofit more attractive to households that want to do various renovation works, but currently cannot find the means to do so.

As highlighted, this research stems from multiple calls in the literature for a more heterogeneous understanding of renovating/retrofitting households. Bearing in mind the context-dependency of the research it is important to compare the research with other relevant literature. Important archetypes that emerge from the research include renovators that are more proactive and planned i.e. 1 and 2, and those where renovation is more of a reaction to a perceived need i.e. narrative 3. The ‘proactive and planned’ renovators are given more depth via the work of Fawcett & Killip (2014). These authors report that “most renovations are planned” but that some renovations involve a “developing series” of emergent changes. Narratives 1 and 2 can potentially be given further detail by being disaggregated between those which take place at one time and those which take place as several projects over time. As highlighted, narrative 4 has similarities to the ‘Stalled’ renovators from the work of Haines and Mitchell (2014). These authors disaggregate their ‘Stalled’ renovator into those that are held up by a ‘lack of finance’ and those by the ‘pressures of life’, with each having associated ‘key features’ and ‘opportunities for retrofit’. Haines and Mitchell categorise their personas using characteristics such as ‘Functional’ and ‘Aesthetic’. Although none of the narratives from the research in this thesis are categorised along the same lines, some narratives have greater affinity with aesthetics (narrative 1) and some with function (narrative 2). Triangulation of ‘narratives’ and ‘personas’ could provide useful depth and an improved knowledge structure, for those seeking to encourage EE retrofit.

5.4. Macro and micro economic investment case in retrofit

The research in chapter 4 sought to add to the political and social perspectives on home retrofit transition by carrying out a *comparative economic assessment* of the macro and micro levels. The economic costs of retrofit and the potential returns on investment are relevant to both government and households. The approach of framing retrofit in terms of its economics receives critical attention at the micro-level in part due to the greater level of research that relates to household level decision-making on energy. Some research into household attitudes report that the economics of retrofit are of paramount importance (Gilchrist and Craig, 2014; Aravena, Riquelme and Denny, 2016), while other sources suggest that there is too much emphasis on the economics of retrofit within policy and general advocacy (Pettifor, Wilson and Chryssochoidis, 2015; Visscher *et al.*, 2016). Some authors are critical of the research methods that are used to deduce economic primacy within household rationales (Wilson, Crane and Chryssochoidis, 2015). The relative importance of an economic framing of retrofit at the macro–level is addressed in chapter 2 of this thesis, but has arguably received little research attention otherwise. This research reveals that the economic rationale for retrofit policy can play major role in some countries, while in others the potential economic benefits of retrofit have been less salient.

The economics are, of course, only a part of the story with respect to both government and household rationales for retrofit. The quantifiable data on the economic costs and benefits of retrofit do, however, allow for a direct comparison of an important part of the macro and micro cases for action. A joint contribution to costs and a shared receipt of benefits result in a complex but interesting case study of some of the distributional aspects of low-carbon energy system transitions. The literature review for this research revealed some studies that have estimated the relative contribution to the *costs of retrofit* from public and private sources in real world examples (see Figure 3). Although the research here involves hypothetical scenarios for the contribution to costs, these are comparable to those from the aforementioned examples (see Figure 4). It is the first research to compare the private and public costs of retrofit with private and public economic returns, and thus the relative overall private and public investment cases.

In this research, the private recipients of retrofit have a better economic case for investment than the public funder. The favourable economic case at the micro-level resonates with the perceived emphasis on the economics of retrofit in household level retrofit research. The household economic case is aided considerably by the impact retrofit can have on a property's value – covering roughly 28% of retrofit investment costs. Whilst it has the potential to be acutely undermined by the inclusion of any cost of borrowing in the overall investment – making up 32% of overall investment in scenarios 3-6.

The inconsistent levels of acceptance of the economic benefits of retrofit within government rationales for policy (see chapter 2) is likely connected to the level of uncertainty and potential variability involved with the public ROIs. Public ROI most consistently comes from net employment gains. Although this benefit had weight in Germany and had profound impacts on the rationales of Ireland and NZ at the point of economic recession, it was treated with scepticism in the UK. The public ROI from re-directed expenditure is perhaps the most uncertain of returns as it depends on a variety of tax rates and human behaviours. Any positive fiscal implications from retrofit are therefore likely to be treated with caution by national governments. The possible uncertainty of ROIs should also be considered in terms of the period of time over which returns might occur. Most returns occur for a period of time after the initial retrofit investment has been made e.g. the implications of energy bill savings, health budget savings and fiscal returns. The returns from employment changes will, however, occur concurrently with the investment in retrofit providing an immediacy of return lacking in most benefits. The long term nature of some ROIs is likely to undermine the potential recognition of their value for public and private funders. The requirement to cover costs upfront and the delayed receipt of any public ROI mean that the costs of retrofit can be covered in one parliamentary term with any public ROI not arriving until the next term (Washan, Stenning and Goodman, 2014). Such delays are likely to politically undermine the value of public ROI as a means of promoting public investment in retrofit. This dynamic of temporally misaligned public costs and public ROI from retrofit help to give rise to calls for party political consensus on retrofit, or for retrofit to be considered a 'national infrastructure priority' (Frontier Economics, 2015).

The public ROIs also do not cover the public investment in any of the scenarios in this research. The fact that there is some positive public ROI from any (private or public) investment in retrofit, however, means that any private investment in retrofit will not only help to achieve government policy objectives, but it also has the potential to provide some form of an economic return to public budgets; a vertical cross-subsidisation. Private investment in private retrofit also has the potential to reduce distributional issues within energy system transition.

The multiple nationally and temporally variable data in the case study mean that the results entail a particularly momentary reflection on the public and private balance of economic costs and benefits. Some of the variability is under the control of governments, for example, tax rates on retrofit goods and services, and on the different forms of energy. Other variables are much less manageable, for example, level of labour intensity and improvements in public health.

The tax regime that currently relates to retrofit in the UK is complicated with some measures receiving a reduced rate and some on a standard rate of VAT. The UK also has relatively low levels of tax on domestic energy use (Vaasa ETT, 2017), resulting in a perverse tax incentive to consume rather than save energy. There are currently EU controls on the levels of VAT that can be applied to goods and services like retrofit or energy. It has been argued that reducing VAT on retrofit and general refurbishment could lead to a boost in activity, and, due to firms currently by-passing the payment of VAT on the 'shadow economy', that public ROIs may not actually fall in such a scenario (Killip, 2008).

Historic levels of private to public funding in the UK have been estimated at levels between that of scenario 1 and 2. Due to the prioritisation of the most cost-effective retrofit measures (Galvin, 2010) if higher levels of private to public investment are to be achieved they are likely to involve the implementation of retrofit measures that overall have an inferior economic case to those that have been implemented thus far. Any success in achieving higher levels of private to public investment are, therefore, highly likely to require a significant improvement in the appreciation of private households of the *non-economic benefits* of retrofit.

5.5. Overall interdisciplinary perspective

This thesis set out to answer the question - why are the relevant actors – government (macro level) and households (micro level) – interested (or not) in engaging in home energy efficiency retrofit activity – what is their rationale for retrofit? The research is multi-level and multi-disciplinary. While each piece of distinct research has addressed the question with respect to a particular level - macro, micro, or macro and micro (comparative) - and each relates to a distinctive academic discipline - policy studies, behavioural research or economics - the following section addresses the practical *interdisciplinary* and *inter-level* connections that exist between the different pieces of research in relation to the thesis research question. This section will also consider whether the particular conceptual theoretical framings of each piece of research section can provide any additional insights to the other pieces.

5.5.1. Practical connections and contributions

How is policy at the macro level informed by the comparative research? The economic *returns* from retrofit occur to the public and private actors in the same way, regardless of who funds the work. It is the economic *costs* that have room for negotiation, rather than the benefits. The comparative paper set out to inform discussion of what an appropriate level of private and public contribution to the cost of retrofit might be. As there are multiple additional components to the rationale for retrofit it does not seek, however, to provide any decisive conclusions as to what the relative private and public contributions should be.

There is a clear case for retrofit to receive public funding. The case is made by the ability of retrofit to deliver otherwise neglected public goods, such as climate change mitigation and a secure energy system. This case is strengthened by the developing recognition of social moral obligations such as fuel poverty or public health inequalities, with the retrofit 'solution' stream able to be linked with these issues. The public *economic case* (the fiscal case) is essentially that public funding of retrofit is a form of *investment* rather than *expenditure,* as it delivers economic returns, as is addressed in chapter 4. As highlighted, the level of public investment in retrofit should not be weighed solely against the degree of public economic return, as the other reasons, public goods and moral obligations, should also influence levels of investment. It could be argued, however, that the amount of public economic return sets a bare minimum for public funding in retrofit.

As is highlighted in the discussion of chapter 4, the public economic returns are highly contingent (on narrow tax differentials) and partly deferred (some returns occur at an unknown point in the future), with these uncertainties likely to produce scepticism amongst public policy decision makers. Chapter 2 shows the public economic rationale can gain relevance in an overall rationale, but that it may be temporary.

<u>How is the household, micro level informed by the comparative research?</u> Although there has been much written about how and why theoretical energy savings from retrofit are higher than what is achieved in reality i.e. comfort taking, performance gaps etc. much retrofit will be, if not, fully, technically cost-effective, very close to it. This is the case for the secondary data (EPCs) we use in our analysis of Kirklees. How relevant these technical calculations are in making the private case for retrofit is debatable (Galvin, 2014b), although it is important that

the economic component of the private rationale should not be down-played to the point of complete insignificance.

Although the research finds a stronger relative economic case for households than for the public purse, the contingencies, uncertainties and irrationalities in the decision making of the respective actors means that this point is of arguably limited relevance. Overall, although the private economic case is stronger, the public actors are likely to be more conscious of the relative cost-effectiveness case, and economic consciousness is ultimately as important as economic opportunity.

An important dynamic of the relationship between macro and micro levels is the provision of private benefits with public funds. The UK government has been criticised for some of the distributional implications of low carbon policies such as the Feed-in-Tariff for renewable generation and the Energy Suppliers Obligations (Ekins and Lockwood, 2011; Walker *et al.*, 2014; Gillard, Snell and Bevan, 2017). Using public funds to promote activity that has private benefit is a politically problematic area of climate policy, and one that can act to inhibit substantial policy action on retrofit. The comparative research in chapter 4 helps to document how the economic costs and benefits of retrofit can pan out on both the private and public sides, and should enable a more enlightened discussion of the future of retrofit funding. The UK treasury are seen as “reluctant to throw public money at improvements that will increase the sale value of private homes.” (BBC, 2017). It is not politically problematic to distribute private benefits with public funds to households that are considered ‘not able to pay’ as this is part of the moral obligation. It is the distribution of public funds to households that are considered able to cover the cost of the work themselves (middle class subsidy, regressive policy) that is considered politically problematic.

In our analysis, the more commonly cited private benefits of energy bill savings are joined by the more emergent property value change benefit. The economic returns considered in this research - private and public - generally (with the exception of redistributed government expenditure) have a positive relationship with the economic investment in retrofit i.e. the more spent the higher the return (see Table 5). The private economic benefits are an important component of the private rationale and although it may be politically problematic to unevenly distribute private benefits with public funds, this uneven distribution is an inevitable part of any public funding. The political sensitivities could be partly alleviated, however, via a different means of administering the public support. An alternative approach to public support for retrofit would be to lower its costs indirectly by lowering any associated taxes. As highlighted in chapter 4 there is a reduced tax rate on some retrofit but not all. Lowering taxes on retrofit goods and services is a means of providing public support without that support being so ostensibly linked with private benefit. Indirectly supporting retrofit via increased taxes on energy (thus improving the cost-effectiveness case of saving energy) presents similar political distributional issues to that faced by public funds for cost subsidies, but does align with a polluter pays principle.

Alongside demand reduction the other broad low carbon option for the residential (and non-residential) buildings sector is that of low carbon energy supply, which I unlikely to have the same degree distributional consequences (Pöyry, 2016). The unequal distribution of retrofit's benefits and costs may act to hinder its political acceptability. The domestic scale of retrofit may, however, act to create spill over benefits for low carbon transition objectives overall. It has been suggested that the installation of domestic level solar panels can have a social spill-over or multiplier type effects, helping to increase the number of solar panels in the area in future (Richter, 2013). Retrofit lacks the visibility of solar panels and the inconspicuous nature of much retrofit has been suggested as one means of explaining its relative unpopularity in comparison to other forms of home refurbishment (Gram-Hanssen, 2014a). Home retrofit will however have some degree of social spill over that is likely to bring the private investment that is of benefit to the achievement of public policy goals.

How is the micro, household level informed by the macro level research? The benefits identified as of the greatest relevance to government policy rationale, also have a degree of relevance to the household level.

What the analysis of the government rationale shows us is that it is important to consider how rationale may affect outcome; will doing the same thing for different reasons result in different outcomes? The characterisation of rationale is broader at the micro level, incorporating the multiple influences that determine attitudes to general renovation, rather than just retrofit. Although, as noted, public reasons for action are likely to be of some relevance to private rationale, how the overall government rationale is constructed may also have implications for households.

The government rationales considered in our research where varied, with some driven by carbon and fuel poverty and others by public health inequality and at times by jobs. A hypothetical government that is solely driven by carbon the benefit and no other, will be looking for maximum energy savings and thus there will be an incentive to support retrofit in households that are not likely to ‘take’ some of the potential energy saving in improved comfort – this group can roughly be seen as the non fuel poor. A government that rationalises retrofit in terms of fuel poverty and public health inequalities is likely to support retrofit in the opposite direction, in the homes that are likely to improve the comfort of their home and thus take less of the potential energy/carbon saving. Jobs will be supported by retrofit in the same way regardless of what type of household the work is carried out on; in chapter 2, emphasis on the jobs rationale coincided with increases in the universal (applicable to all households) budgets. Due to the universal applicability of retrofit policy that is implemented with a carbon rationale and the targeted application of retrofit policy that is implemented with a more distinctly fuel poverty or public health rationale, overall government rationale will keenly affect how relevant retrofit support is to different households. As highlighted, public funds for private benefit is only a political problem when the public funds are directed toward those that are considered ‘able to pay’. The able to pay population is essentially the same as the non-fuel poor population.

Co-benefits or multiple benefits recognition within a rationale is (as mentioned in chapter 1) partly a means of improving the political acceptability of policy, with different reasons given for a particular action to different audiences. The stated rationale acts as a way of marketing the policy, but the details of the policy’s design - whether it is universal or targeted at certain social groups - helps to reveal a different perspective on the rationale. Ultimately, in the case of retrofit, having different government rationales for the same action matters, as the rationale for public intervention influences what private actors will be involved.

Home energy retrofit, like many other actions that involve public and private collaboration, involve different reasons from government and different reasons from households for the same action. The web of rationality that has been considered in this thesis emanates from the multiple benefits advocacy narrative that is associated with energy efficiency. By thoroughly articulating the rationales of the two main actors, this thesis has provided a clearer description of why government and private households might be interested in home energy retrofit. By more fully understanding *why,* it becomes easier to answer the questions of *how* – can home energy retrofit be implemented – but also of *if* – what is retrofit likely to be ultimately able to achieve within the broader low carbon energy system transition.

<u>How the micro level research informs the governmental, macro level:</u> section 5.3 sets out some of the potential policy implications of the findings from the micro level research.

5.5.2. Conceptual connections and contributions

The following section considers the extent to which the theoretical framings used in each piece of research relate to each other, and whether future research at each of the levels could learn from the framings of different disciplines.

There is, inevitably, some overlap in the theoretical framings of government and household decision making. Both theories of the policy process and household behaviour at times use a 'stages heuristic' – see the 'Policy Cycle' and different forms of agenda (Cairney, 2012f) or the stages of retrofit decision-making of Klöckner and Nayum (2016). The idea of trigger events i.e. occasions when retrofit is more likely to take place, like moving house, are used by Wilson et al (2015) to understand why households might act on energy efficiency. While at the policy level, Kingdon (1995) refers to the principle of focusing events in his multiple stream framing, and crises, "real or perceived", are sometimes used in relation to punctuated equilibrium theory (Cairney, 2012e).

The theories of the policy process and of human behaviour that are most commonly cited in the academic research that relates to retrofit, both routinely seek to play down the role of the neo-classical economic foundation of self-serving rationality in decision-making. At the micro-level there is perceived to be a "rationalisation discourse" in retrofit research that emphasises individual choice and rationality (Maller and Horne, 2011). While at the macro-level the perception is that all theories of the policy process have bounded rationality fundamentally embedded within their models (Cairney, 2012c). As highlighted, an important difference between the decision-making theories at the household level compared to that of the government level is that household research is more likely to have applied consequences, via the design of policy or promotional campaigns, while research at the policy level largely remains descriptive. This difference may help to explain the sensitivity to theoretical framings being perceived as inappropriate at the micro-level. The complexity of the government decision making process, involving a vast number of individual actors would suggest that the bounded rationality framing would be a more immediately salient at the macro level. While it is important to recognise that there are a number of reasons why neither political institutions nor households operate in a fully rational, self-serving manner, it is also important to not completely dismiss the simplified rational choice model, and to assume that rationality and self-interest have no bearing on decision-making. It is appropriate in such a scenario to be somewhat inclusive with respect to theories, with different theories having utility at different times (Bhaskar, 2010; Chang, 2014).

Theoretical lessons from the micro level: The micro-level research brought together what are considered by Wilson et al. (2015) to be the proximate and the ultimate influences on retrofit decision making. Incorporating the theoretical inclusivity of critical realism both forms of influence can be used to explain why households might retrofit. The research sought to address some of the criticisms of research in this area from Wilson et al., for example, the homogeneity that is implicit in rational choice conceptions of behaviour i.e. that economic incentives and more information are enough to change a populations behaviour.

The proximate influences on retrofit are those that are most commonly identified as its ‘drivers’ i.e. energy savings, comfort improvements or awareness of environmental issues. The ultimate influences are considered to be the conditions of daily life and how the ‘meaning of a home’ is perceived by a household. In the micro-level research, it was felt that it was important to include all the different perceived forms of influence rather than simply focusing on those influences that were considered to be under represented in existing retrofit research. Due to its ability to incorporate multiple influences and to develop a heterogeneous understanding of a population, and as a means of “combining the economic and sociological bases for behaviour” Q-methodology was also considered particularly appropriate for this interdisciplinary research intention (Wilson and Dowlatabadi, 2007)

The proximate and ultimate (often termed 'distal') distinction is seen in other areas of research on causation. In evolutionary biology for example, proximate causes have been interpreted as those that are manifest during the life of an organism, while the ultimate influences relate to those that shaped an organism's genetics (Francis, 1990). Research that considers the causes of homelessness interestingly frame the proximate influences, such as increased housing costs, as 'micro-level', with the 'macro-level' causes considered to be the "structural forces that generate a population of poor people at risk of homelessness" (Lee, Tyler and Wright, 2010).

The proximate and ultimate framing was not encountered in relation to government policy in the period of this research. If such a framing was applied to retrofit policy, the proximate influences could be interpreted as the multiple benefits that underpin the research, or the identified market failures and public goods. The ultimate influences for retrofit policy could be seen to be conditions such as an inefficient housing stock, that ultimately mean large amounts of fossil fuels have to be used to generate heat and light, or that people find it prohibitively expensive to live in adequately warm conditions. Beyond this mechanism, some observers may find themselves turning their attention to the liberal, system of economic governance that sees the cost of climate change remaining external to the cost of energy, and the accepted moral issues of fuel poverty and public health inequality remaining a sideshow to the primary goal of economic growth and greater levels of material consumption.

Although it is beyond the boundaries of this thesis to deliver a full interpretation of what the different proximate and ultimate influences might be on government retrofit policy, it has delivered a novel perspective on how the rationale for policy can be affected by multiple different influences. As has been highlighted, a multiple benefits framing is applied to other topical issues e.g. vegetarianism, cycling and shale gas fracking. Research that considers the different rationales that emanate from these framings could utilise the theoretical structure of stratified levels of influence i.e. proximate and ultimate. Such a framing could provide insight on both the overt, public facing rationale but also draw attention to some of the background conditions and any potential covert rationale that orientates a government, an organisation or an individual toward a certain path.

<u>Theoretical lessons from the macro level:</u> The multiple streams theory of the policy process could provide some fresh insights to the process of household decision making. 'Retrofit' could remain as the 'solution' with the problems being essentially the 'drivers' or misalignments in the 'conditions of daily life' that may motivate a decision to retrofit. The essence of MS theory is that policy development is not a linear process of problem identification, followed by the development of an appropriate solution. Solutions often exist in a pool as well developed options that, via their respective advocates, are on the lookout for the problems that can bring them the required attention. If retrofit at the micro level is thought of in the same way, then retrofit advocates are seeking the problems from a household's perspective that retrofit can address. The connections between problems - akin to the approach taken in the macro level research - may provide suitable piece of comparative research to that carried out in chapter 3.

The analysis of decision theory for the research in chapter 3 was limited to the theory that was commonly seen in relation to retrofit and did not comprehensively cover the extremely wide literature base on decision theory. The application of an MS framing to the micro level would resonate somewhat to the sociological perspective on decision making, by drawing attention to the requirement for consideration of structural social issues when thinking about the decision making.

5.6. Further work

The previous section (5.5.) has highlighted the potential application of different theoretical framings to the different areas of research, and how this could be developed into novel research topics. The following section will consider some other opportunities fro further work that have emerged from the thesis.

It could be argued that all retrofit ultimately takes place at the point of the household, and thus this is where research on implementing retrofit will naturally focus. Those that speak from a sociological perspective, however, observe that much of the discourse that surrounds environmental change places responsibility at the micro-level, deflecting responsibility away “from the many institutions involved in structuring possible courses of action” (Shove, 2010). Research, like that in chapter 2, that is focused on the action of governments and other institutions may be a useful point of academic inquiry within general environmental and climate research (Hughes and Urpelainen, 2015).

Such inquiry could examine in detail the question of *why*, the full rationalisation, that relates to the decision-making of organisations and individuals with respect to topical issues. Outside of government policy, other organisations face the prospect of decision-making with a potentially selfish economic, or a selfless moral framing. Some organisations are, for example, encouraged to divest from fossil fuels at times because it is argued they should “show moral leadership” (Guardian, 2017) and at other times because of the risk to the value of their stock (Guardian, 2016). Arguments are also routinely made for immigration in both economic and social, moral terms – although rarely simultaneously (Eaton, 2017). Multiple or at least dual benefits framings are a common political and rhetorical tool and the study of their rationalisation and implications is a clear avenue for further research.

The research for chapter 3 entailed the most amount of research time and background reading. Ultimately, around 70 interviews were carried out with households, predominantly on a face-to-face basis. Conventionally Q is used to describe solely psychological subjectivity, for example, in relation to values (Albizua and Zografos, 2014), conceptualisations (Howard *et al.*, 2016) or perspectives on political and social issues (Cotton, 2015). The approach taken in this research is somewhat different in that it is not just interested in psychological subjectivity (influences on the decision to renovate) but also in what could be termed physical subjectivity (the conditions of daily life that led to the renovation and how the renovation process is experienced). The statements in our concourse bring together both proximate and ultimate influences on renovation, which arise from the conditions of daily life and the expectations of consequence (Wilson, Chryssochoidis and Pettifor, 2013; Kastner and Stern, 2015; Wilson, Crane and Chryssochoidis, 2015). This adaptation of the methodology could be used in other research areas but requires a carefully gathered concourse. The concourse in this research was indebted to the existence of a comprehensive background literature. The basic ideas of Q-methodology are relatively simple, and its reputation as both quantitative and qualitative was part of its attraction in this research. Its application however, “requires substantial effort” (Durning, 1999). The effort that has gone into the concourse gathering in this research means that the prospect of further analysis with the same concourse of statements is something that should be considered

5.7. Limitations

The limitations of the research have been highlighted as part of each chapter. Here we will reflect again on some of these.

In line with the logic of critical realism it is important to stress that each piece of research produces only momentary or partial truths that are useful when the context in which they are produced is fully understood. As highlighted there are distinct limitations to the association of causes with effects in macro scale (policy-making) environments (Lawson, 1997; Pawson, 2006). The 'big picture' narratives reveal some differences between the four contexts and as a result the macro level research acts to instigate further research on the topic of government policy rationale.

The perceived 'rationalisation discourse' of household decision making with respect to retrofit is thought to have given rise to an undue emphasis on retrofit as an exercise in economic calculation. Multiple authors argue that approaches to retrofit policy thus far have focused too much on the adjustment and communication of the economic costs and benefits and that this approach will have a very limited impact on retrofit uptake (see 1.2.5.3). The possibility and the implications of framing *retrofit policy* as economic or social are considered in chapter 2 and section 5.2. The suggestion that is made is that an economic rationale may appeal more than a solely social one to policy makers with limited funds and infinite demands. Theories of decision-making at the level of government should not be related uncritically to those at the micro-level but it is worth pausing to consider the general discontent around the perceived economic rationality discourse at the micro-level and the suggestion in this research that governments may be more attracted to an economic rather than a social rationale. The instances cited as examples of economic influence – Germany compared to New Zealand, and the impact of the jobs benefit in Ireland and NZ at particular times – all entail economic benefits *alongside* more social benefit i.e. carbon in Germany, carbon/fuel poverty in Ireland and public health in NZ. Indeed, it may be the temporary nature of the economic benefit – being prominent at times of economic recession – that leads to its impact being more obvious, building on the bases of longer-lasting social rationales like climate change, fuel poverty and health benefits.

The economic and social dichotomy is also disturbed by the overlap of social and economic in all benefits, for example, the effective economic framing of climate change by reports such as the Stern Review (Stern, 2006). Ultimately, the approach of framing government decision-making in terms of what sociological perspectives at the micro-level might consider externalised factors, may be subject to criticisms similar to that applied to the ‘drivers and barriers’ framing at the micro level i.e. there is too great an expectation placed on agency, even if it is at governmental organisational level.

The narratives in chapter 3 are intended to be recognisable and representative of renovating households. It is important to note that they are derived from a certain population i.e. generally urban homeowners in the North of England. As highlighted, triangulation of narratives with other attempts at household experience descriptions could provide an improved knowledge structure for home energy retrofit advocates.

In chapter 4, the research was largely based on secondary data and is as a result reliant on the accuracy of this data for its results. A review of available sources of data was carried out in the data gathering stage of this research. It was also highlighted in chapter 4 that by only considering the economic case and not the wider components of both private and public rationale, that the research presents findings that have a limited overall consequence.

The explanation of why discount rates were not applied in chapter 4 is given in section 4.2.3. As social and private discounting is normally done at different rates in order to make the results more comparable and to avoid some of complexities in calculation that were outlined, it was decided that no discounting would be used. If discount rates were applied they would only be to some of the returns. Private returns from energy bill savings would continue for the life time of the retrofit (estimated to be 20 years) and thus would potentially be subject to significant reduction from the level used in the research. The return from improved property value could be assumed to occur at a certain point in the future and also discounted. This calculation would, however, need to account for any baseline increase in property value. Public returns from net employment would be happen alongside the retrofit investment and thus would be subject to minimal discounting. The public health benefit would also occur instantaneously but also into the future with an assumed end point that could relate to evidence on the impact of retrofit on excess winter deaths. The redistributed public expenditure is partly related to the degree of energy bill savings and thus would occur some distance into the future and thus be subject to substantial discounting. Overall, both public and private returns would be subject to discounting although as both sources of private return could be discounted and the main source of public return, net employment, would only be slightly discounted it is fair to assume that if some form of discounting were to be used the private case would be more negatively impacted.

5.8. Conclusion

For most people (with declining rates of interest the further that one goes from the equator) (Lorenzoni, Nicholson-cole and Whitmarsh, 2007) the idea of climate change and, more importantly, the idea that climate change is something they should worry about, is a distant and largely irrelevant issue in their daily lives (Taylor *et al.*, 2014; Taylor, Bruin and Dessai, 2014). Climate change mitigation and adaptation, however, are quite likely to entail tremendous amounts of change in the way that societies around the world live. The impasse between that scale of action needed and the level of attention that people pay to the issue is partly the inspiration for this research.

Climate change mitigation and adaptation actions have in recent years been increasingly framed in terms of their perceived co-benefits, with this framing rightly identified as a means of improving the political and social acceptability of the large scale changes that are needed to address climate change (Aunan, Fang, Vennemo, Oye and Seip, 2004; Smith, 2013b). Energy efficiency has played a prominent role in climate mitigation policies since their inception (Giddens, 2009). Due to the scattered, rebounding nature of energy impacts from efficiency improvements, the action lends itself particularly well to a framing that entails additional impacts. As a result, energy efficiency is now framed as an action that has 'multiple benefits'.

As a result of these complex emerging rationales for action this thesis sought to consider in detail the question of *rationale for action,* or what are the reasons given for acting on climate change. To consider this the research focuses on the two key stakeholders in low carbon transition – the government and the people. These two actors most keenly interact in one of the primary early mitigation actions in many countries around the world – energy efficient retrofit of residential buildings.

Retrofit has for several years been considered a low carbon option that involves 'low hanging fruit' or no/low regret options. As a result, there has been a significant amount of government policy mainly seeking to persuade, rather than coerce, households into retrofit. These actions have largely been carried out in a cost-effective first fashion with varying degree of public funds used to cover the costs of measures that often have significant private benefit. Although difficult to accurately measure there is thought to have been some success in reducing the amount of home energy use in countries that have taken substantive action on retrofit – with the UK (Rosenow *et al.*, 2017), Germany (Galvin and Sunikka-blank, 2014), and the USA (Crandall-Hollick and Sherlock, 2016) examples of falling energy demand in residential buildings. There are, however, concerns in some quarters about what the ultimate social potential of retrofit might be, or even that we may be reaching economic or technical boundaries (Galvin, 2014b).

At a policy level, retrofit is not, however, just about carbon reduction. As demonstrated in chapter 2 stimulating activity that makes millions of people's homes warmer has multiple impacts. Retrofitting to most people is not retrofit at all, but home refurbishment or renovation, a practice that every household is engaged with in some way. Households may consider it an action to help stop climate change, but it is just as likely to be thought of in relation to a multitude of other stratified influences. Some of these influences are economic, with emerging and adapting economic framings of retrofit at both the micro and macro-levels. As with other climate mitigation actions or general relations between government and citizens there are important, distributional consequences to retrofitting people's homes.

With three distinct empirical pieces of work that are built on the research base and existing methods of established disciplines, this thesis is most appropriately viewed as multi-disciplinary. As each of these disciplinarily distinct pieces of work has been carried out by the same researcher the author can consider themselves to have "had training in at least two conventional disciplines" and thus be described as interdisciplinary in some quarters (Sovacool, 2014). The research can be viewed as "additive" and as involving knowledge creation rather than just knowledge exchange (Siedlok and Hibbert, 2014; Pellegrino and Musy, 2017).

By providing an evidence base that is at times directly applied to the implementation of retrofit at the micro level (chapter 3), at other times more focused on understanding the overall macro picture (chapter 2) or the distributional issues between the two levels (chapter 4) with little prescriptive intent, this thesis has sought to develop a novel interdisciplinary perspective that can help to inform this issue. Through development of an interdisciplinary, somewhat generalist perspective on a complex, joined-up problem the researcher seeks to provide knowledge that is transferrable and relevant to other social and environmental domains. Ultimately, however, the research has sought to shed light on the extent to which energy efficient retrofit can affect the issue of climate change mitigation and whatever other benefits this might entail.

5.7. References

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7. Appendix

A. Chapter 2 interview procedure outline and questions

Interviews were between 45-60 minutes and were recorded for analysis post-interview.

They were semi-structured with questions to prompt discussion.

Questions

- Please tell me what you know about the origins of energy efficiency retrofit policy in your country – when it was first introduced, what form it took then and what the rationale for policy was at this time?
- Please tell me what you know about any changes that have taken place to the policy since its introduction (in chronologic order)?
- Did these changes involve alteration to the scale, the scope or the policy mechanisms used within the policy topic?
- Could you tell me why you think these changes took place?
- Do you think the rationale for policy was the same now as it had been before the changes?

The above questions were repeated until the discussion of policy reached the end point of the analysis period 205-2014. At this point was reached the interviewee was asked

- Can you please summarise what you think the predominant overall rationale for retrofit policy has been between its inception and now?

The interviewee was then asked about the perceived benefits of retrofit policy that had not been discussed. If benefit X had not been mentioned then…

- Could you please tell me what relevance you think X had to the overall rationale for policy and how this compared to other benefits that have been mentioned in association with retrofit policy rationale?

And finally the interviewer listed the pre-selected benefits of interest for the analysis and asked the interviewee

- Which of the perceived benefits of retrofit policy do you think are the most relevant to the overall rationale for policy?

B. Chapter 3 contextual data

The recorded contextual details of the 24 participants (P-set) is given below. The P-set is not meant to be representative of the entire renovating population of the UK. In line with the logic of Q-methodology, however, the P-set is meant to try and gather a wide variety of potential subjects, as this should help to generate a variety of different narratives. Variety, in this context, can be understood in a number of ways. We have tried to achieve as much diversity in the recorded contextual data as possible i.e. a spread of ages, inhabitant groups, property types etc. As this should allow for a diversity of narratives. The developed narratives are not meant to be representative of the entire renovating population but should represent a selection of recognisable narratives.

Contextual data

Table B1: Participants and co-inhabitants age at point of analysis

Age	Participant	Co-inhabitant
18-25	0	1
25-34	5	5
35-44	9	5
45-54	4	6
55-64	5	1
65 and over	1	2
Total	**24**	**20**

Table B2: Types of inhabitant groups of the participating households

Inhabitant group	Participants	
Family	11	45.84%
Grown up family	3	12.5%
Non-familial group	2	8.33%
Couple	3	12.5%
Single	5	20.83%
Total	**24**	**100%**

Table B3: Property types of the participating households

Property type		
Detached	5	20.83%
Semi-detached	9	37.50%
Terraced	6	25.00%
End of terrace	4	16.67%
Bungalow	0	0.00%

Flat	0	0.00%
Total	**24**	**100.00%**

Table B4: Number of bedrooms of each participating household

Number of bedrooms	Participants	
1	0	0.00%
2	5	20.83%
3	9	37.50%
4	8	33.33%
5	2	8.33%
Total	**24**	**100.00%**

Table B5: Property age of the participating households

Property age	Participants	
Pre 1900	4	16.67%
1900-29	9	37.50%
1930-49	6	25.00%
1950-69	2	8.33%
1970-89	2	8.33%
1990-2016	1	4.17%

Total	**24**	**100.00%**

Table B6: Length of tenure of the participating households

Length of tenure (years)	Participants	
0-4	6	25.00%
5-8	6	25.00%
9-12	5	20.83%
13-16	1	4.17%
Over 16	6	25.00%
Total	**24**	**100.00%**

Table B7: Combined household income of the participating households

Household income (£)	Participants	
0-25,000	5	20.83%
25,000-50,000	6	25.00%

Over 50,000	13	54.17%
Total	**24**	**100.00%**

Table B8: Level of energy renovation of the participating households

Energy renovation level	**Participants**	
Minimal energy	10	41.67%
Moderate energy	8	33.33%
Substantial energy	6	25.00%

- Minimal energy: one energy measure or less
- Some energy: more than one measure had an energy focus
- Substantial energy: majority of work carried out had an energy focus

Table B9: Level of overall renovation of the participating households

Overall renovation level	Participants	
Minimal	3	12%
Moderate	11	46%
Substantial	10	42%

- Minimal: one room only renovation
- Moderate: more than one room renovation
- Substantial: most rooms in the house received some renovation work