Programme Area: Smart Systems and Heat

Project: Consumer Response and Behaviour

Title: External Factors Report

Abstract:

This report was prepared for the ETI by the consortium that delivered the project in 2013 and whose contents may be out of date and may not represent current thinking. The objective of this piece of work was to identify the key external factors that are expected to impact energy-related consumer behaviour in the period leading up to 2050 and provide an assessment of how these external factors are likely to impact people's needs and behaviours. Based on this assessment the consortium developed a number of scenarios for how these key factors may change and evolve to 2050, and then provided an analysis of the expected impact of these external factors on consumer needs and behaviour, under the different scenarios identified.

Context:

The delivery of consumer energy requirements is a key focus of the Smart Systems and Heat Programme. The Consumer Response and Behavior Project will identify consumer requirements and predict consumer response to Smart Energy System proposals, providing a consumer focus for the other Work Areas. This project involved thousands of respondents providing insight into consumer requirements for heat and energy services, both now and in the future. Particular focus was given to identifying the behaviour that leads people to consume energy - in particular heat and hot water. This £3m project was led by PRP Architects, experts in the built environment. It involved a consortium of academia and industry - UCL Energy Institute, Frontier Economics, The Technology Partnership, The Peabody Trust, National Centre for Social Research and Hitachi Europe.

Smart Systems and Heat (SSH) Technology Programme

Work Area 5 Consumer Response and Behaviour

WP5.3 External Factors

D5.3 External Factors Report

Final

22 March 2013

1. Executive Summary

1.1 Report Objectives

The objectives of this report are as follows:

- to identify the key external factors that are expected to impact energy-related consumer behaviour in the period leading up to 2050;
- to present a high level assessment of how these external factors are likely to impact people's needs and behaviours
- to develop a number of scenarios for how these key factors are likely to change and evolve to 2050, and provide an analysis of the expected impact of these external factors on consumer needs and behaviour, under the different scenarios.

As one of the early work packages in the Consumer Response and Behaviour project, WP5.3 establishes a baseline understanding to inform the upcoming work on the consumer engagement activities (WP5.4, 5.7), feed into the modelling work (WP5.6) and aid in the development of the solution scenarios and solution scenario characteristics (WP5.5, 5.8).

This Work Package seeks to address the following Research Questions set by the Consortium.

RQ5. Which external factors, that could affect consumer needs, behaviour, motivation or rationale, are likely to change over time?

RQ6. How would these factors be expected to impact consumer needs, behaviour, motivation or rationale?

1.2 What is an External Factor?

We define factors as external if they cannot be directly influenced by the wider activity associated with the development and deployment of smart energy systems – therefore the smart solutions to be trialled in the project are defined as internal. Under this definition, there is a spectrum of external factors, from those based on global developments that are external to all UK parties, to those that can be influenced by UK industry and/or policy. An example of how this division was envisioned is shown in Figure 1.

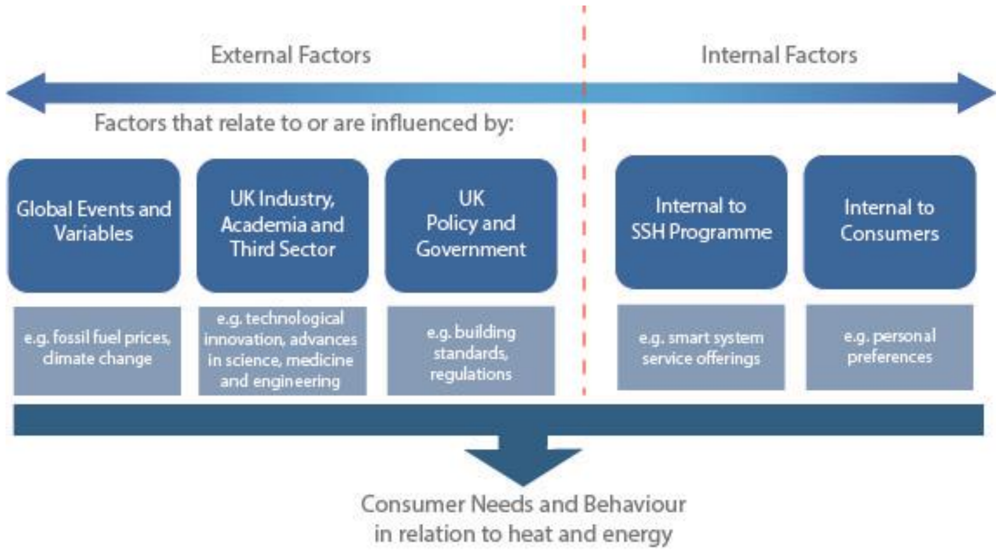

Figure 1: What makes a factor external?

1.3 Identifying the key External Factors

Using a combination of collaborative workshops and external consultation with experts on the various PESTLE (political, economic, social, technological, legal and environmental) factors, a wide range of external factors have been explored which had the potential to impact consumer needs and behaviour. In order to evaluate the significance of these factors and select the key factors that were investigated further for this report, we focused on the following criteria.

- **A high and direct impact on consumer needs and behaviour for energy use**. A number of external factors were discounted because they did not have a direct enough impact, or were secondary rather than root factors. For example, 'social norms' was considered too broad as well as secondary factor which is affected by age, education, household size and income.
- **Strongly expected to change out to 2050, highly uncertain out to 2050, or have a changing relationship with energy needs and behaviour to 2050**. For example, we did not shortlist the urban/rural split of population as this is projected to change only marginally to 2050. The proportion of the population that lives in urban areas is expected to fall slightly – from 63% in 2001 to around 62% in 2028.[1]
- **Be sufficiently well defined, to allow research to be carried out**. For example, rather than investigating 'social norms' which could potentially encompass a wide range of factors that govern society's behaviour, we chose to focus on individual PESTLE factors, each of which could drive changes in social norms.

Based on this assessment, we narrowed down the initial list of external factors drawn up in a brain-storm exercise to the 18 key External Factors shown in the table below.

PESTLE Framework	Key External Factors
Political	• **EU Policy** – influence on UK energy policy and consumer attitudes • **National Policy** – provision of support, guidance and direction to the public • **Local Policy** – impact of localisation on climate change policy implementation
Economic	• **Income** – average consumer income, income distribution and disposable income • **Cost of Low Carbon Technologies** – absolute and relative costs, relationship between upfront and running costs • **Housing Tenure** – changes in levels of home ownership • **Fuel and Electricity Prices** – domestic gas and oil prices, grid electricity prices
Social	• **Ageing population** – increase in elderly population • **Education** – rising levels of education • **Household Size** – changing household sizes, rise of single person households
Technological	• **Energy Efficiency** – advances in smart technologies, improved efficiencies for appliances, retrofit products and microgeneration • **Diversity of Energy Generation** – role of low carbon technologies • **Electrification** – impact of mass market electrification, increase in electricity demand
Legal	• **Building Regulations** – stricter standards for emissions reduction • **Energy Sector Regulation** – market controls, maintaining security of supply, reducing carbon emissions • **Energy Performance Labels** – impact on consumer decision-making and product availability
Environmental	• **External Temperatures** – projected temperature increases, changes in heating and cooling demand • **Extreme Weather Events** – changing weather patterns and consequences, impact on energy generation and consumer awareness of climate change

Figure 2: Top External Factors by PESTLE category

1.4 Assessing the Impact of the key External Factors

As predicted, the existing literature and case studies suggest that the chosen top 18 external factors are expected to have medium or high overall impacts on consumer needs and behaviour, with over half expected to have a high impact.

Six of the group (income, age, education, technological progress, energy performance labels and Building Regulations) have a low uncertainty of change, meaning the evidence surrounding the expected change to 2050 is the most robust. This has helped form a solid basis for scenario development, and will be particularly useful in **WP5.5** in the development of solution scenarios.

The following table, a summary of each of the external factor profiles is presented in Figure 3. The figure should be read with the following understanding.

- **Expected Change**: According to existing research, what is the level of likely change for each external factor between now and 2050?
- **Uncertainty of Change**: Does the existing research provide strong evidence that the external factor is likely to take a certain trajectory or are there a variety of projections?
- **Impacts on Needs/Behaviour**: Considering both the external factor as it exists in 2013 and the expected change to 2050, is the impact on consumer needs and behaviour expected to be high?
- **Overall Impact**: Taking into account the previous three categories, what is the overall impact of each external factor?

Each of these four variables has been marked as high, medium or low.

		Expected Change	Uncertainty of Change	Impact on Needs/Behaviour	Overall Impact
Political	EU policy	M	M	M	M
	National policy	H	H	H	H
	Local policy	M	H	H	H
Economic	Income	H	L	H	H
	Low carbon technology costs	H	H	H	H
	Fossil fuel prices	M	H	H	H
	Grid electricity prices	H	H	H	H
Social	Housing tenure	L	H	M	M
	Aging population	H	L	H	H
	Household size	H	M	M	M
	Education	H	L	M	M
Tech.	Electrification	H	H	H	H
	Efficiency improvements	H	L	H	H
	Diversity of energy supply	M	H	M	?
Legal	Energy sector regulation	M	M	H	H
	Energy performance labels	L	L	H	M
	Building Regulations	H	L	M	H
Env	Severe weather events	M	M	H	M
	External temperatures	M	M	H	M

Figure 3: Linking external factors to consumer willingness and ability to take up and use smart solutions

2. External Scenarios

Based on the analysis of the key external factors, the project team took on the challenge of developing scenarios to 2050 that illustrate how external factors could lead to different future worlds for which solution scenarios for heat and/or mobility could be developed. These scenarios are intended as a tool for examining a wide range of futures and are not predictive with any degree of certainty – the considerable timescale to 2050 makes this level of scenario planning speculative and imprecise.

In developing these scenarios, the team agreed to the following assumptions.

- **Focus on varying factors that are likely to have the greatest impact, including those with certain and uncertain trajectories.** The scenarios will not be able to encompass every possibility, but they should ensure that the main uncertainties around factors that will affect the success of solutions (in terms of consumer uptake and use) are captured.
- **Consistency with meeting the 2050 climate targets, and internal consistency and plausibility, in the context of meeting our climate goals**. Since this project is investigating smart solutions in the context of our 2050 climate goals, all of our scenarios assume that the 2050 climate targets are met.[2] To ensure that they are consistent with meeting these targets, our scenario development has been informed by the scenarios produced by the ETI's ESME model, DECC's Carbon Plan as well as those produced by the Committee on Climate Change.
- **A manageable number of scenarios**. For the scenarios to be useful in solution development, it is also important that we produce a manageable number, even if this means that other plausible states of the world may exist in the future that are not covered by these scenarios.

The scenarios are framed in terms of a three-dimensional matrix of three critical elements for the future uptake and usage of smart system solutions. These elements are as follows:

- **Technological progress** (impact of advancements in smart system technology and their role in improving efficiency, including domestic appliances, retrofit products and microgeneration may lead to increased efficiency of production as well as leading to a decrease in the relative cost of technology and their subsequent affordability for consumers),
- **Government involvement** (related to the level of government involvement in pushing the low carbon agenda), and
- **Consumer willingness** (to take up and use smart solutions. By considering willingness, more accurate judgments can be made on the overall impact on behaviour that is likely to result from each change in external factor)

These elements do not represent entirely separate groups of external factors. Instead, each external factor can be viewed in terms of its influence and dependence on the three above elements. For example, income will depend on Government policy, the influence of income will depend on the money required to adapt smart energy solutions (hence the level of technological process) and income will therefore affect willingness to change. The three elements will themselves be interdependent, each having an effect on the other.

Scenarios were developed based on high and low trajectories of each element, leading to 8 scenarios based on different combinations of high and low futures of each element. These 8 scenarios were then filtered down to four by bringing in one of our assumptions as an eliminating factor – the assumption that our carbon targets are met. Based on this assumption, if at least two of the critical factors have negative trajectories, it is unlikely that carbon targets will be met for that future. These scenarios were then eliminated from further development, leaving four scenarios that we will be discussing further in the next section. Figure 4 outlines these different combinations.

Scenario No.	GOVERNMENT POLICY	TECHNOLOGICAL PROGRESS	CONSUMER WILLINGESS	LIKELY TO MEET CARBON TARGETS?
1	Weak	High	High	Yes
2	Strong	High	Low	Yes
3	Strong	Low	High	Yes
4	Strong	High	High	Yes
5	Strong	Low	Low	No
6	Weak	Low	High	No
7	Weak	High	Low	No
8	Weak	Low	Low	No

Figure 4: Combinations of high and low trajectories of three key elements for future scenario development

Figure 5 summarises how each of the 18 key factors varied for each scenario (where an upwards arrow suggests an increase, a downwards arrow suggests a decrease and a horizontal arrow suggests little change from present day conditions).

Factor	Scenario ONE	Scenario TWO	Scenario THREE	Scenario FOUR
EU policy	↓	↑	↑	↑
National policy	↓	↑	↑	↑
Local policy	↓	↑	↑	↑
Income	↑	→	↑	→
Technology costs	↓	→	↓	↑
Housing tenure	→	→	→	→
Fuel and electricity prices	↑	↑	↑	↑
Aging population	↑	↑	↑	↑
Education	↑	→	↑	↑
Household size	→	→	→	→
Energy efficiency	↑	→	↑	→
Diversity of energy generation	→	↑	↑	→
Electrification	↑	↓	↑	↓
Building Regulations	↑	→	↑	↑
Energy sector regulation	↓	↑	↑	↑
Energy performance labels	↑	↓	↑	↑
External temperatures	↑	→	↑	↑
Extreme weather events	↑	→	↑	↑

Figure 5: Trajectories of external factors under each scenario

2.1 Outputs and Next Steps

The outputs of this report primarily consist of evidence from the literature to shape and constrain future models and plans (e.g. the model (**WP5.6**) and field trial location criteria (**WP5.9**)), scenarios to conceptualise future worlds in which smart solutions could succeed or fail (e.g. for solution scenarios and characteristics (**WP5.5** and **WP5.8**)) and descriptions of key external factors and their impacts (to inform the primary consumer research (**WP5.4** and **WP5.7**)).

The external factors literature review, however, has also served to identify key areas where there is limited available evidence (i.e. many of the social and economic factors are well covered, whilst other PESTLE factors have limited evidence on their impact on consumer needs and behaviours). This may help inform the research areas to focus on in the later part of the project (e.g. the research in **WP5.7**) once consolidated with the findings of the main literature review in **WP5.1**. This identification could also inform the direction of future research beyond this project and beyond the Smart Systems and Heat Programme.

At the current stage of the project, there are two immediate uses of the External Factors work.

- **Workshop and Interview Probes for WP5.4** – Methodology development sessions for the deliberative workshops in WP5.4 (four workshops of 40 people each, including breakouts of 10 participants each) identified that the most useful output of the External Factors work for the qualitative fieldwork would be the description of factors and their impact on consumer needs and behaviours. The scenarios, it was felt, were too abstract or complex to present "cold" to consumers and that asking them to imagine life in these futures would be less useful for this stage of the work than exploring their current situation. As such, a list of probes (**Appendix C**) for each external factor was produced (providing facilitators with example triggers (what might be said by participants in discussions to provide an opportunity to smoothly introduce the factor), example prompts (questions to put to the group) and a rationale for the prompt to allow facilitators to adapt the prompts to fit the discussion. At the time of writing, this list of probes has been used at the first workshop with positive feedback from the research team as to its usefulness in helping provoke useful and relevant discussion within the scope of the groups. This list of probes will also be used in development of the in-home interviews.

- **Draft Locational Criteria Presentation for D5.9(i)** – The first deliverable for WP5.9 seeks to provide the ETI with some initial criteria by which to assess potential areas for the Phase 2 field trial. At this stage of the project, the inputs are based on work completed to date, supported by previous experience of the consortium. As the External Factors work is one of the earliest pieces of work it is, therefore, a crucial input into this deliverable. To date, the systematic approach to identifying key external factors has provided a useful model for crafting the category framework and the evidence from the literature will provide key inputs to criteria that would prevent (or be essential) for a field trial that will be relevant for 2050.

Similar applications from the external factors work will be developed as the other Work Packages begin later in the project (e.g. external factor scenarios shaping the work of the solution scenarios team in WP5.5), and these inputs will be highlighted in the relevant later deliverables.

Content

1. Introduction

1.1 Aims

The acceptance criteria for this deliverable, as agreed with ETI, are as follows.

- Comprehensively identify the significant identifiable external factors that are expected to impact on energy-related behaviour in the period to 2050.
- Present a high level assessment of how these external factors are likely to change people's needs, behaviours, motivations and rationale with regard to their energy-related behaviour and usage to the extent that this information is available from the review.
- Present a meaningful number of scenarios for how these key factors are likely to change and evolve to 2050.
- Provide an analysis of the expected impact of these external factors on consumer requirements to 2050, under the different scenarios.

These criteria represent the aims of the report.

1.2 Project Integration and Context

As one of the first Work Packages in the Consumer Response and Behaviour project, WP5.3 focuses primarily on providing input to the rest of the project by reviewing relevant literature on external factors to provide empirical information and interpretation grounded in past experience. It can be viewed as the "sister work-package" to **WP5.1 (Literature Review)** which, instead, focuses on literature *directly* covering consumer needs, behaviour and response and/or technical measures and energy.

The findings from WP5.3 will feed in to the primary consumer research in **WP5.4** and **WP5.7 (Primary Consumer Research (Phase1)** and **(Phase 2)** respectively**)** via **WP5.2 (Research Methodology)**. Outputs from WP5.3 include a list of key external factors and their descriptions to be explored with qualitative workshop participants and input into quantitative research instruments to explore differences in External Factor impact across the population.

The limits and constraints imposed by external factors on consumers will help in the development of the consumer behaviour model in **WP5.6 (Consumer Model)**. The model will also be informed by the quantitative data on external factors generated in WP5.7, mentioned above.

The future direction of external factors and the evidence for their impact on consumers and solutions will inform the initial development of **WP5.5 (Solution Scenarios)**, where the external factor scenarios detailed in this report will also provide a useful tool for evaluating ideas as they are developed. The external factor considerations in the consumer model (WP5.6) and the quantitative research (WP5.7) will assist in the final development of **WP5.8 (Solution Characteristics)**.

Finally, the key factors and their impact on consumers (now and future) will provide an important input into the development of **WP5.9 (Field Trial Location Criteria)**. This will be particularly important for the first deliverable **D5.9(i) Draft Location Criteria Presentation** where external factors will dictate many of the key variables that would help select a field trial location that is both feasible and designed to trial a system that will be applicable for 2050.

A summary of the outputs from WP5.3 is detailed in Figure 1.

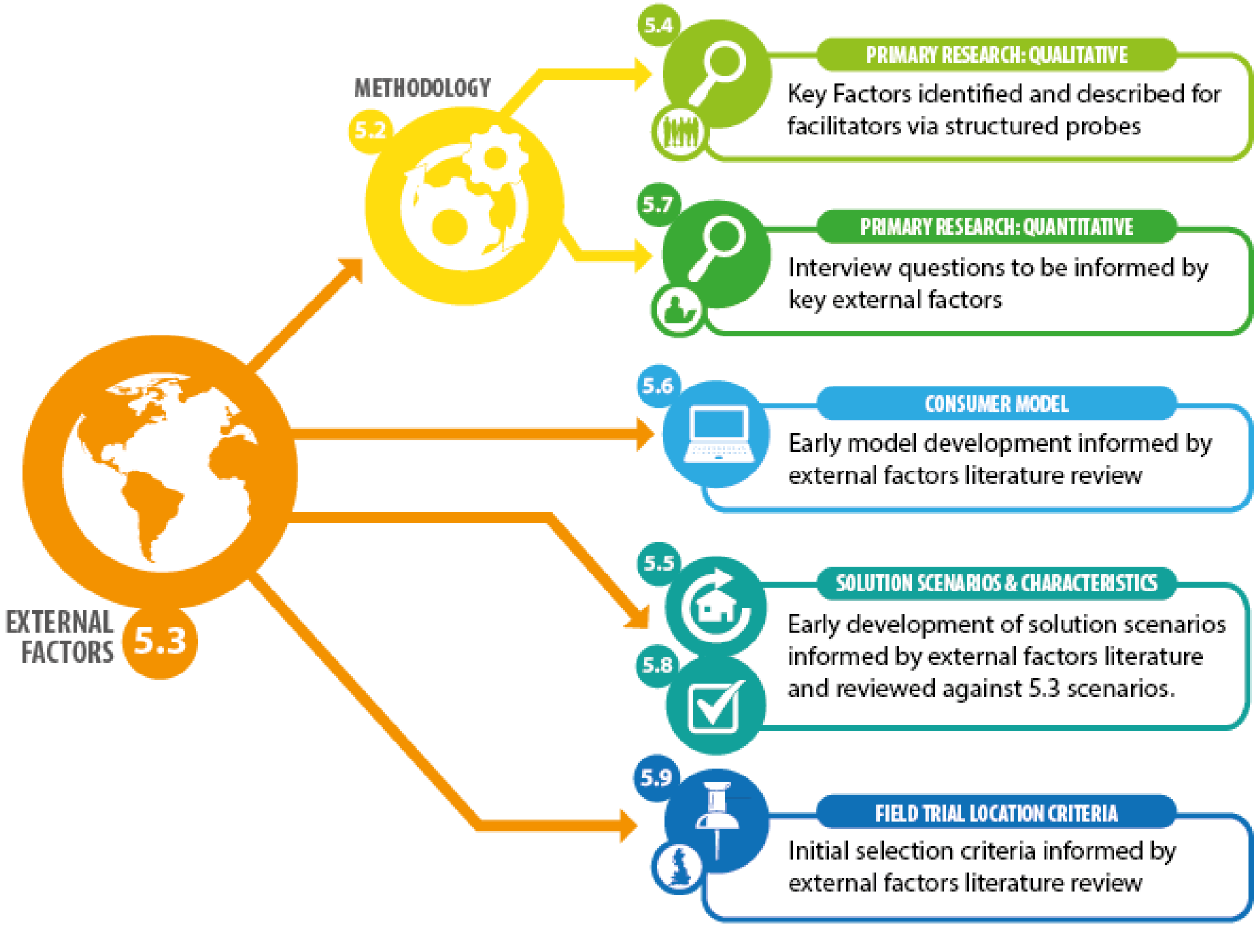

Figure 1: Situation of External Factors work in the wider project Work Packages

1.3 Work Package 5.3 – External Factors

Our understanding of the complex relationship between consumers and external factors is based on the following definitions.

- '**Needs**' – the fundamental needs that could influence energy-related behaviour, as listed in the draft CRaB paper "Categorisation of Needs" (see Appendix A).
- 'Needs' become '**Motivations**' when they actually influence behaviour.
- '**Behaviour**' – the outward manifestation of a consumer's activities that leads to a fulfilment of 'Needs'.
- '**Rationale**' – the explanation that the consumer would offer for a particular 'Behaviour'.

In this report we look at external factors and their potential role in influencing the conversion of a 'motivation' into a 'rationale' for behaviour. This report primarily focuses on a high-level understanding of the factors that could influence behaviour, as a starting point for the development of a more detailed understanding of needs, motivations, and rationale in the forthcoming work packages.

This Work Package seeks to address the following Research Questions set by the Consortium:

RQ5. Which external factors, that could affect consumer needs, behaviour, motivation or rationale, are likely to change over time?

RQ6. How would these factors be expected to impact consumer needs, behaviour, motivation or rationale?

1.4 What is an external factor?

An external factor is defined for this project as a constraint and/or opportunity that the future external environment will place on consumers which they have no direct control over.

Factors are defined as external if they cannot be directly influenced by the wider activity associated with the development and deployment of smart energy systems. Likewise, factors that cannot directly be influenced by individual consumers are also considered as external. Under this definition, there is a spectrum of external factors, from those based on global developments that are external to all UK parties, to those that can be influenced by UK industry and/or policy. An example of how this division was envisioned is shown in Figure 2 below.

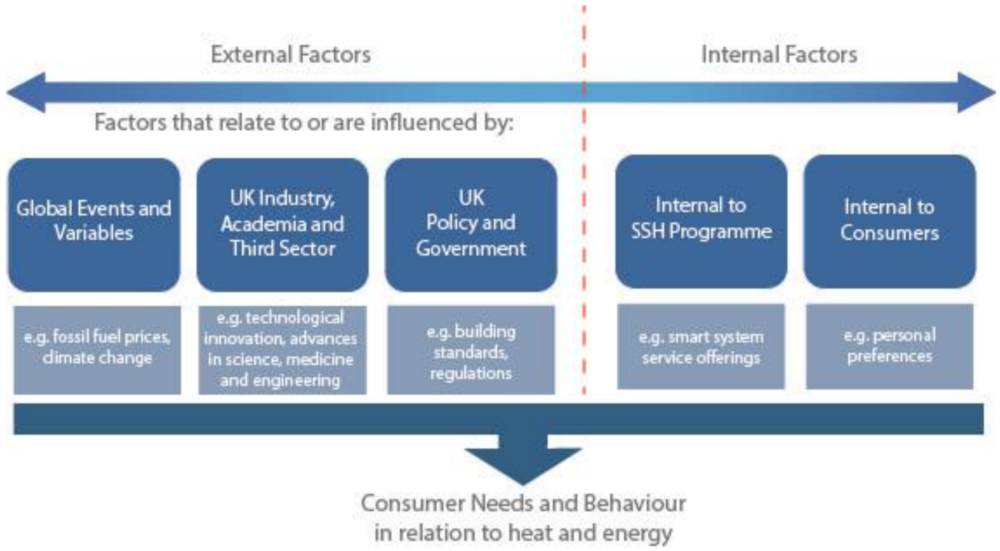

Figure 2: What makes a factor external?

External factors have been categorised using the PESTLE framework (political, economic, social, technological, legal and environmental). While we acknowledge that these constraints and opportunities may have little influence on changing a consumer's basic needs, they may impact the hierarchy of these needs. External factors may also have an impact on motivations or rationale which could modify consumer behaviours.

1.5 Report Structure

The main body of this report details the following outcomes.

- **Identification of key external factors and analysis** – as selected from the literature and expert engagement and classified under the PESTLE framework, and characterised using projections for change and their impact on consumer needs, behaviour, motivation and rationale.
- **Development of external factor scenarios** – which describe four potential futures under which these factors could vary and how these variations would impact consumers.
- **Conclusions and next steps** – summarising the key lessons learned, specific applications in other work packages, and key recommendations.

2. Identification and Analysis of Key External Factors

This section describes our approach to identifying the key external factors which will be discussed in detail as the report progresses. It then sets out a summary analysis of the impact that these external factors may have on consumer needs, behaviour, motivation or rationale for energy use.

2.1 Methodology

The external factors discussed in this study were identified by the following research activities:

- a structured brainstorming session to identify and prioritise external factors attended by ETI, ETI partners and Energy Endeavours consortium partners;
- a review of the literature and an analysis of historic case studies; and
- consultation with external experts in specific PESTLE fields.

A mind map of external factors was developed as a starting point for the initial brainstorming workshop on external factors (see Figure 3).

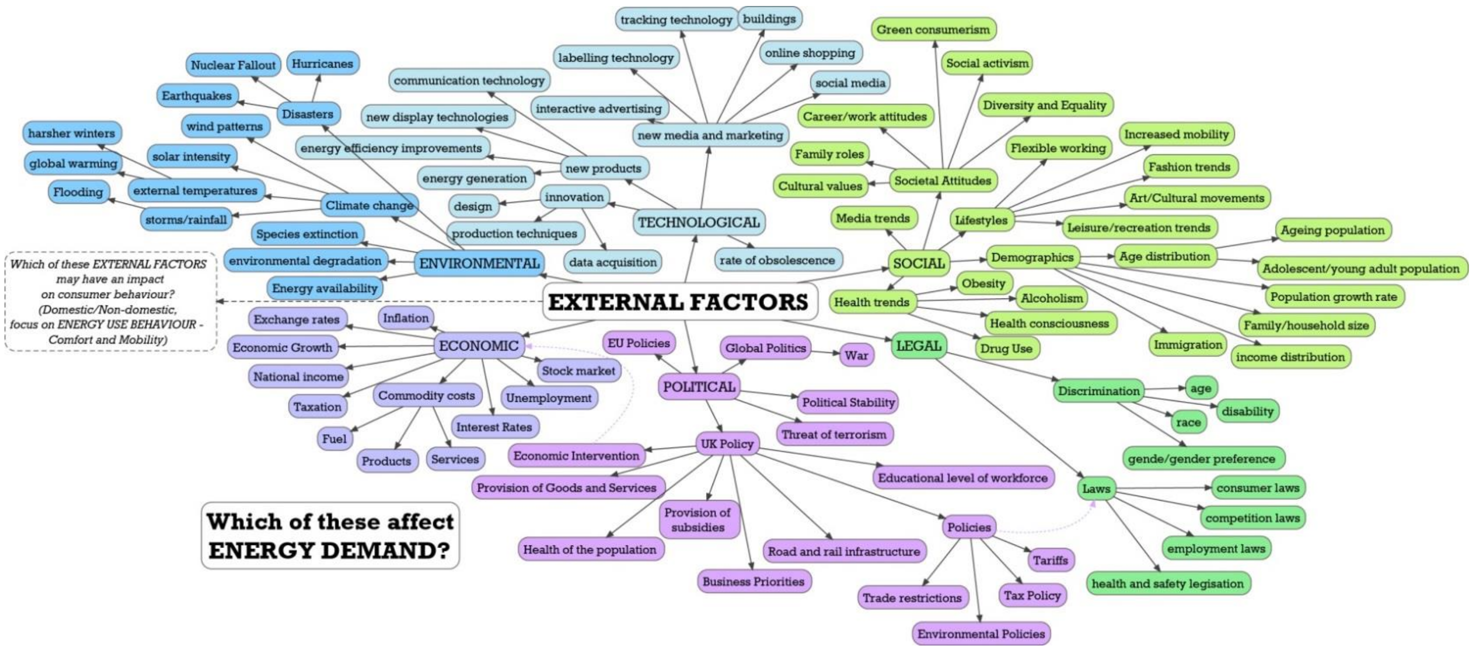

Figure 3: Initial visualisation of possible external factors

During this initial workshop, participants were asked to rate the importance of external factors on a scale of 1-10. Using this as a basis, a long-list of top external possible factors was developed which was then interrogated further using the following criteria, designed to identify which external factors have the most potential to influence consumer uptake and usage of smart solutions from now to 2050:

- **Factors that are likely to have an impact on consumer needs, behaviour, motivation or rationale for energy use.** For something to be an important external factor in the context of this project, it has to have a relationship with consumers' energy use. During the selection process, a number of external factors were discounted because they did not have a direct enough impact on energy use. Factors were also analysed and structured in order to determine whether they were actually a secondary factor that could be linked to a more inclusive "root factor" - for example, 'social norms' was seen as a secondary factor which was affected by age, education, household size and income.

- **Factors that are expected to change to 2050, or are highly uncertain to 2050.** An insight into change and uncertainty would be a powerful tool in characterising the landscape to 2050, as it is the interaction between these that will inform how our approaches to the introduction of a smart heat and energy should be adapted between now and 2050. Therefore as a secondary criterion we also sought to select factors that would be expected to change significantly; which have an uncertain trajectory; or are likely to have a changing relationship with energy behaviour from now to 2050. For example, the urban/rural split of population was not shortlisted as this is projected to change only marginally; the proportion of the population who lives in urban areas is expected to fall only very slightly – from 63% in 2001 to around 62% in 2028.[3]

- **Be sufficiently well defined, to allow meaningful research to be carried out**. For example rather that investigating 'social norms' which could potentially encompass a wide range of factors that govern society's behaviour, we chose to focus on individual PESTLE factors, each of which could drive changes in social norms.

2.2 External Factors Analysis

The following tables describe the long-list of top external factors generated after the workshop, all of which could have a high impact on consumer needs and behaviour. We subsequently chose a priority short-list from among these factors to focus in on the report based on the criteria mentioned above. The factors ultimately chosen are highlighted in bold. In the table, 'Y' should be understood as 'Yes', while 'N' represents 'No' and '?' suggests we were unable to find substantial evidence to support a definitive answer.

Political Factors	IMPACT	CHANGE	CERTAINTY	EXISTING LITERATURE	STRUCTURE
	Direct impact?	Expected change to 2050?	Well-defined?	Strong existing research?	Is it a secondary factor?
EU Policy	Y	Y	Y	Y	N
UK National Policy	Y	Y	Y	Y	N
Local Policy	Y	Y	Y	Y	N
Planning Policy	Y	Y	Y	Y	Y*
Energy Policy	Y	Y	Y	Y	Y**
Tax/Subsidies	Y	Y	Y	Y	Y**
Civil Disobedience	Y	?	N	N	Y
Wider transport infrastructure	N	Y	N	Y	Y
Heritage/conservation	N	Y	Y	N	Y
Social policies (i.e. Welfare)	Y	Y	N	Y	Y**
* Related to Local Policy ** Related to UK National Policy					

Economic Factors	IMPACT	CHANGE	CERTAINTY	EXISTING LITERATURE	STRUCTURE
	Direct impact?	Expected change to 2050?	Well-defined?	Strong existing research?	Is it a secondary factor?
Income (disposable income and income distribution)	Y	Y	Y	Y	N
Fuel prices	Y	Y	Y	Y	N
Costs of low-carbon technologies	Y	Y	Y	Y	N
Housing tenure	Y	Y	Y	Y	N
Economic decision-making	Y	?	Y	N	Y
Costs of the welfare state	N	Y	N	N	Y

Social Factors	IMPACT	CHANGE	CERTAINTY	EXISTING LITERATURE	STRUCTURE
	Direct impact?	Expected change to 2050?	Well-defined?	Strong existing research?	Is it a secondary factor?
Aging Population	Y	Y	Y	Y	N
Education	Y	Y	Y	Y	N
Household size	Y	Y	Y	Y	N
Other demographics	Y	Y	N	N	Y
Extent people are at home	Y	Y	N	N	Y
Social norms	N	Y	N	N	Y
Household dynamics	Y	Y	N	N	Y

Technological Factors	IMPACT	CHANGE	CERTAINTY	EXISTING LITERATURE	STRUCTURE
	Direct impact?	Expected change to 2050?	Well-defined?	Strong existing research?	Is it a secondary factor?
Efficiency Improvements	Y	Y	Y	Y	N
Diversity of Energy Generation	Y	Y	Y	Y	N
Electrification	Y	Y	N	N	N
New infrastructure	Y	Y	N	N	Y
Obsolescence of technology	N	Y	N	N	Y
Increased reliability	Y	Y	N	N	Y
New production – control techniques, tracking and communication	N	Y	N	N	Y
Virtualisation of lifestyles	Y	Y	N	N	N

Legal Factors	IMPACT	CHANGE	CERTAINTY	EXISTING LITERATURE	STRUCTURE
	Direct impact?	Expected change to 2050?	Well-defined?	Strong existing research?	Is it a secondary factor?
Building Regulations	Y	Y	Y	Y	N
Regulation of Energy Sector	Y	Y	Y	Y	N
Energy Performance Labelling	Y	Y	Y	Y	N
Data protection	Y	Y	Y	N	Y
Consumer protection	N	Y	N	N	Y
Product standards	Y	Y	N	Y	Y
Energy efficiency standards (products, homes, etc.)	Y	Y	N	Y	Y*
Employment commercial (e.g. working hours and opening hours)	Y	Y	N	N	N
IP Law	N	Y	Y	N	N
* Covered by Building Regulations, Regulation of Energy Sector and Performance Labelling.					

Environmental Factors	IMPACT	CHANGE	CERTAINTY	EXISTING LITERATURE	STRUCTURE
	Direct impact?	Expected change to 2050?	Well-defined?	Strong existing research?	Is it a secondary factor?
External temperature	Y	Y	Y	Y	N
Extreme weather events	Y	Y	Y	Y	N
New sources of energy	Y	Y	N	N	N
Speed of change of temperature	N	Y	N	Y	Y
Pollution – air quality, global and local scales	N	Y	N	Y	Y
Rising CO_2 levels	N	Y	N	Y	Y
Acidification under environmental degradation	N	Y	N	Y	Y
Overheating from external temperature conditions	Y	Y	N	Y	Y
Drought	Y	Y	Y	Y	Y

2.3 Top Key External Factors

Based on the analysis of these Key External Factors Tables, we were able to narrow the list to 18 top external factors, which are presented as follows. We have grouped the prioritised factors into political, economic, social, technological, legal and environmental factors using the PESTLE framework:

2.3.1 Political

- **EU Policy** – EU Policy has a direct impact on setting targets and influencing energy policy within the UK, as well as the role of strong EU leadership in influencing consumer attitudes toward these initiatives.
- **UK National Policy** – Strong national policy provides support, guidance and clear direction which suggests to the public that the government is heading towards a more energy efficient and sustainable future, influencing consumer confidence and trust.
- **Local Policy** – Localisation, or the shift towards local authorities taking responsibility for energy consumption, national policies that place more responsibility on individuals, communities and local councils with regards to finding solutions for climate change and governance issues.

2.3.2 Economic

- **Income** - Average consumer income, disposable income and income distribution in the UK would influence consumer purchasing decisions and perceptions of affordability.
- **Costs of low-carbon technologies** – The absolute and relative (to conventional alternatives) costs of low-carbon and smart technologies, in synergy with the other economic factors, could also influence consumer purchasing decisions and perceptions of affordability. This factor is related to technological innovation.
- **Fossil fuel prices** – Changes in domestic gas and oil prices may influence the affordability of heat and mobility provision from fossil fuels, leading to a shift in fuel source preference as well as an increased awareness of energy issues. Increases in the cost of both fossil fuel and electricity without a corresponding increase in income may lead to more sustainable and creative ways of reducing energy use.

- **Electricity prices** –Changes in grid electricity prices may influence the affordability of heat, appliance use and mobility provision from the national grid – cheaper electricity prices compared to fossil fuels could lead to a shift towards electrification not just in terms of heat but also mobility. Rises in electricity prices, on the other hand, similar to fossil fuel price increases, may lead to a general increased awareness of energy issues.
- **Housing tenure** – Changes in the level of housing ownership may influence consumer purchasing decisions and require a radically different approach in terms of the solution scenarios for market incentivisation and consumer engagement. If there is a shift towards ownership, then the impact of retrofit and intervention on property value may become significant. If there is a shift towards a rental market, tenant engagement becomes a priority issue, the role of green leases may be instrumental and the value of the retrofit may be driven by rental value, and the operational benefits to the tenants may become a bigger hook for the market.

2.3.3 Social

- **Aging population** – The increasing average age of the population will impact on general consumer preferences and social norms, as well as the service requirements for heat and mobility. This factor is also related to income and the affordability of energy and technology.
- **Household size** – Changing average household sizes, and the rise of single-person households will impact on housing demand, occupancy and energy usage patterns, and the shift towards or away from family-oriented needs, motivations, rationale and behaviour.
- **Education** – Rising average levels of education and the level of energy efficiency awareness in schools and universities may greatly affect consumer perception to 2050, particularly if the shift in education happens now – today's students and schoolchildren will become the workforce and financial decision-makers in the run-up to 2050.

2.3.4 Technical

- **Electrification** – The electrification of heat and transport on a mass scale throughout the 2020s and beyond, and consequently, the increase in overall electrical demand, will have an impact on the suitability and design of smart systems.
- **Efficiency Improvements** – The impact of advancements in smart system technology and their role in improving efficiency, including domestic appliances, retrofit products and microgeneration may lead to increased efficiency of production as well, leading to a decrease in the relative cost of technology and its subsequent affordability for consumers. On the other hand, stagnation in technological innovation would necessitate solution scenarios that rely on existing supply chains and technology to deliver heat and mobility to 2050 – with this constraint, how can targets be met?
- **Diversity of energy generation** – The role of low carbon technologies in meeting the Government's 2050 carbon targets, including large-scale renewables, microgeneration and the integration of EU energy markets will be an influence in the availability of green energy for the grid, which is of particular interest should there be a massive shift towards electrical demand.

2.3.5 Legal

- **Regulation of Energy Sector** – Independent regulation in controlling wholesale and retail markets and networks may be instrumental in maintaining the security of our energy supply and reducing carbon emissions. This reliability may consequently increase consumer trust and make acceptance of mass-scale retrofit solutions and smart system deployment more feasible.
- **Energy Performance Labelling** – Energy performance labelling has an impact on consumer decision making and the potential to take the least efficient items off the market.

- **Building Regulations** – Stricter Building Regulations for new (and, in theory, existing homes) may be instrumental in reducing domestic carbon emissions and meeting the UK's 2050 targets if coupled with strong enforcement and regulatory consistency.

2.3.6 Environmental

- **Extreme Weather Events** – An increase in extreme weather events, such as changing rainfall patterns, leading to droughts, floods, storms and heavy snowfall may have an impact on energy generation, quality of life, heating and cooling requirements and consumer awareness of climate change. The increased intensity of extreme weather events may also have structural implications for certain technological solutions, as well as health and safety risks.
- **External Temperature** – Increasing external temperatures and subsequent changes to heating and cooling demand may lead to increased heating and cooling requirements and overheating risk. It would also tend to increase consumer awareness of climate change.

2.4 Assessing the impact of the key external factors

In the summary profiles presented in this section, we first describe in more detail how each factor is expected to change between now and 2050, and identify the uncertainty around this change, and then consider the likely impact on energy-related behaviour associated with that factor. To assess the impact on energy behaviour, we carried out a systematic analysis of the impact of these factors on needs, motivations and rationale, based on our findings from the literature review, expert engagement activities, and the analysis of historic case studies.

These case studies have been included in the following section with the relevant external factor. We examined these historic examples examined to provide a better understanding of the impact of various external factors on consumer behaviour in relation to energy usage. The analysis has fed into our identification and assessment of external factors presented elsewhere in the report.

Where possible, we have presented at the start of the section indicative estimates of the magnitude of the impact of each external factor on consumers' energy behaviour. These illustrate the expected significance of the factors as drivers of future behaviour, holding other factors constant and extrapolating from existing relationships. For each factor, we have rated four aspects of impact as high, medium, low, or unknown.

2.4.1 EU Policy

Expected change to 2050	**MEDIUM**	
Uncertainty of change	**MEDIUM**	
Impact on Energy Needs and Behaviour	**MEDIUM**	
Overall Impact	**MEDIUM**	*Image courtesy of Yanni Koutsomitis*
EU Policy has a direct impact on setting targets and influencing energy policy within the UK, as well as the role of strong EU leadership in influencing consumer attitudes toward these initiatives.		

Overall Impact

EU policy has been selected as an external factor because a strong future EU leadership could spur international momentum towards a sustainable low carbon economy with implications for energy policy that could affect consumer needs and behaviour.

Political stability and unity are central to establishing a sustainable energy system such as a 'supergrid' which could potentially provide cheaper energy for consumers.[4] However, a lack of EU-wide standards (e.g. for smart metering) and proposals for maintaining any such standards may jeopardise the feasibility of such an opportunity.[5]

The EU also funds substantial research and development within the UK and elsewhere in Europe.

Expected Change to 2050

The change is anticipated to be medium as the EU has already committed to cutting its emissions to 20% below 1990 levels by 2020 and EU leaders have endorsed the objective of reducing Europe's greenhouse gas emissions by 80-95% compared to 1990 levels by 2050.

Uncertainty around Change

Again, a medium rating is given as there is some uncertainty over whether the EU will pursue its targets over the longer term, with some Member States wishing to avoid incurring the costs of decarbonisation. There is also uncertainty around the means by which these targets would be met. For example, the development of an EU supergrid has a high degree of uncertainty surrounding it.

The level of international solidarity (agreements that underpin the international economy) could affect the scales by which the UK will respond to energy problems, i.e. low solidarity as considered in one scenario led to more localised solutions to energy problems on the UK scale. In this scenario, energy increasingly became a diplomatic bargaining tool.[6]

Energy suppliers cited existing bilateral agreements (e.g. between UK and France) as a pattern that may be followed in the future. However, they note that these agreements are made to meet national needs rather than European needs, indicating doubt over the future of EU-wide agreements.[7] Other NGOs suggest that a silo-based way of planning is evident across the EU but particularly in the UK where there is growing euro-scepticism[8] and plans for an "in-out" referendum within the next parliament.

Potential Impact on Energy Needs and Behaviour

Owing to the uncertainty of future EU policy, UK consumers' energy needs, and behaviour could be affected in a number of ways so we have rated this relationship as medium. Strong future EU leadership could spur international momentum towards a sustainable low carbon economy with implications for energy policy. EU policy drives investment in green technology in energy markets.

For example, it can affect the electricity price, as in the case of the EU's 2020 renewable energy target, which impacts on the electricity price faced by UK consumers.

Strong EU policy could also increase UK consumers' motivation to act to reduce emissions, to the extent that it can show that countries aside from the UK are taking strong action and benefiting from it.

Energy policy, energy security and climate change are high on the UK Government's agenda and also prominent internationally, demonstrated by the G8 and G20 which have pledged towards more open markets within the EU and improved transparency beyond. However, other Member States do not always share the same enthusiasm, as evidenced by, for example, the failure of the EU to implement a coordinated response to the impacts of Russia's repeated disputes with neighbouring states over gas supplies. UK-based energy suppliers cite very different market conditions as a barrier to entry in other Member States, particularly in Member States with a state-owned utility provider and, consequently, monopolised market.[9]

Related Factors

This external factor covers the following secondary factors:

- Energy Policy
- Tax/Subsidies

This external factor has a strong relationship to these other key external factors:

- UK National Policy
- Diversity of Energy Generation
- Building Regulations

2.4.2 UK National Policy

Expected change to 2050	**HIGH**	 Image courtesy of Ree Saunders
Uncertainty of change	**HIGH**	
Impact on Energy Needs and Behaviour	**HIGH**	
Overall Impact	**HIGH**	
Strong national policy provides support, guidance and clear direction which suggests to the public that the government is heading towards a more energy efficient and sustainable future, influencing consumer confidence and trust.		

Overall Impact

The importance of political leadership in terms of influencing consumer behaviour is likely to increase, with a growing number of policies and programmes that suggest to the public that the government is heading towards a more energy efficient and sustainable future. The regularity of change is likely to be frequent, both with each election and within each parliament. Some national energy policies will be put in place this decade, others are set to achieve a significant impact by 2050.

Expected Change to 2050

The expected change is high as the Government will need to show increasing leadership on reducing energy use in order to meet carbon targets.

Uncertainty around Change

The UK experiences significant change with each change of Government and the impact of the change will be high.

Since privatisation, the energy markets in the UK have undergone major reform several times. It is not certain therefore that the current reforms will persist to 2050.

In 2008 the UK created the world's first legally binding Act to reduce carbon emissions to 2050. However, it is not fully certain that successive governments will choose to abide by this Act.

Potential Impact on Energy Needs and Behaviour

Given the present market failures, national policy will be crucial if action to tackle climate change is to occur. Evidence suggests that clear government leadership can lead to successful behaviour change.

Although there are numerous discussions on encouraging local authorities to take on more responsibility with regards to reducing energy consumption, there is evidently a strong belief that a prominent National Governmental leadership is essential for success.[10] Indeed, an individual's behaviour is decisively influenced by the organisational culture within a country, in addition to individual and material factors. The organisational culture in turn is influenced by political decisions and legislation.[11]

Overall, numerous studies, both within the UK and in the EU, have highlighted the importance of strong political leadership to provide direction for a sustainable future. This concept is supported by the observation made by Cox et al. (2012) that the organisational culture of our society is significantly influenced by political decisions and legislation.[12]

In one study[13], the main agreement across four scenarios and throughout the document was that, in order to achieve the Government's targeted reduction in CO_2 emissions, strong government leadership is essential, with a particular emphasis given to the importance of long-term policies. However, present political and economic measures currently tend to focus on the short term[14]. Consumers are more likely to believe and make a positive response to information provided by regulatory agencies than by energy providers or private business.[15]

In a survey conducted by the European Commission, 66% of participants in the UK believed that energy issues should be dealt with by the national government, compared with only 8% of respondents who felt it should be addressed at a local level, strengthening the notion that the public expects the national government to take initiative and provide leadership. Overall, the majority of people across those interviewed felt that governments should promote energy efficiency. In terms of new measures to help reduce consumption, 46% thought the government should provide more information on how to use energy efficiently, while 37% said the government should adopt higher efficiency standards for energy consuming equipment. [16]

One example is of the Government's action is the commitment to a mass roll-out of smart meters in the UK for domestic consumers and small businesses, from 2014 to 2019. The government's leadership will be vital in the programme's success, as its wider impact will depend on the details of how smart meters are installed, the nature of the interventions linked to the smart meters and the manner and quality of their implementation.[17]

However, some authors have identified the absence of action taken by local, national and international governments as creating a lack of trust between consumers and the government in promoting energy efficiency and renewable energy.[18] This lack of trust has been exacerbated, for example, by the Government's feed-in tariff policy, with the level of tariff being significantly reduced because the Government was not expected the high level of uptake by the public.[19]

Related Factors

This external factor covers the following secondary factors:

- Energy Policy
- Tax/Subsidies
- Social Policies
- Civil Disobedience

This external factor has a strong relationship to these other key external factors:

- EU Policy
- Local Policy
- Education
- Diversity of Energy Generation
- Regulation of Energy Sector
- Building Regulations

2.4.3 Local Policy

Expected change to 2050	**MEDIUM**
Uncertainty of change	**HIGH**
Impact on Energy Needs and Behaviour	**HIGH**
Overall Impact	**HIGH**

Image courtesy of Bart Everson

Localisation, or the shift towards local authorities taking responsibility for energy consumption, national policies that place more responsibility on individuals, communities and local councils with regards to finding solutions for climate change and governance issues.

Overall Impact

Local policy in the UK has been included as an external factor due to the diversity within local authorities surrounding action on energy and climate change. A shift towards local authorities taking responsibility for energy behaviour is already evident within the UK.

Expected Change to 2050

The concept of "Building a Big Society" has led to policies that aim to give more responsibility to individuals, communities and local authorities to solve climate change problems so policy could vary significantly at the local level with a medium expectation of change.

Uncertainty around Change

There is some greater uncertainty over the direction of local policy – the Climate Change Act does not specify any actions locally and change can vary greatly between local authorities. Therefore, uncertainty is classified as high.

Potential Impact on Energy Needs and Behaviour

It is possible that some consumers respond more to locally driven initiatives than national policies, since the local policy approach can be often be more integrated, holistic and faster to react.

If it is more flexible or specific to a local area, the more likely it is that the policy will succeed. The relationship is therefore highly rated.

Some documents argue that the issue of sustainability is increasingly becoming the responsibility of individuals, communities and local councils as opposed to being the responsibility of the Government. There are claims that applying energy targets at a local level makes them more meaningful and "less daunting."[20] Similarly, there is a need to put an equal amount of pressure on individual energy consumers as is put on large scale energy suppliers in order to reduce consumption levels.

A study by Altan (2010)[21] emphasises the importance of ensuring the Government does not impact on competition between industries, implying that the Government needs to be cautious about how much to intervene.

In a survey conducted by the European Commission, only 8% of UK respondents felt that energy-related issues should be tackled at a local level, compared with 66% of respondents who thought this area should be dealt with by the national government. The authors suggest that the overall small response to the local level may result from the lack of awareness regarding the role of local government in promoting energy efficiency and renewable energy. [22]

Some examples of ways in which responsibility is being shifted toward individuals are through the provision of information and attempt to educate the population on building literacy, although this is not limited solely to local policy. [23] It has been emphasised however that measures such as the provision of information and environmental education will not be successful if they stand alone, and therefore needs the support of other measures to drive behaviour change amongst individuals. Similarly Gardener[24] describes the provision of information as being a "necessary but insufficient condition for change" explaining that information needs to be relevant to the individuals reading it in order for them to understand the reason for changing their behaviour or for choosing particular products or services.

The scenarios developed by Mander et al.[25] take into consideration the likely impact of liberalism where there would be a dependency on individual choice and a belief in market forces, although the actual extent of the role that liberalism is likely to take in the future is not specified.

An example of a successful local government body reducing emissions is in Woking, UK. [26] The Corporate Energy Efficiency Strategy (CEES) was introduced in 1990 and exceeding the targeted reduction of energy consumption, resulting in a reduction of 52% over 10 years. This was achieved predominantly through the provision of CHP and renewable energy generators, although a raised awareness amongst residents would have also impacted on the reductions.

In London, the Mayor's 'Low Carbon Zones' piloted 20% carbon reduction by 2012 across 10 areas. Local authorities worked with residents to reduce their carbon emissions. In Brixton, a £2.8m investment from E.ON to retrofit social tenure homes was made possible as part of the local authority's commitment to the Low Carbon Zone.

Related Factors

This external factor covers the following secondary factors:

- Planning Policy
- Tax/Subsidies
- Heritage/Conservation

This external factor has a strong relationship to these other key external factors:

- National Policy

2.4.4 Income

Expected change to 2050	**HIGH**	
Uncertainty of change	**LOW**	
Impact on Energy Needs and Behaviour	**HIGH**	
Overall Impact	**HIGH**	*PRP stock image*
Average consumer income, disposable income and income distribution in the UK would influence consumer purchasing decisions and perceptions of affordability.		

Overall Impact

Income varies greatly between consumers and it is a significant external factor to consider with regards to their response and behaviour. For example, those with lower incomes will be less able to respond to higher fuel prices by installing technologies to reduce energy demands or generate their own energy, without subsidies.

Expected Change to 2050

The OECD (Organisation for Economic Co-operation and Development) projects that real UK GDP per person is predicated to grow by 29% between now and 2030, and 119% between now and 2060.[27] In a 2011 study using data up to 2009, PWC estimated that real UK GDP would grow by 37% between 2011 and 2025, and 140% between 2011 and 2050.[28]

Projections are not available on future changes to the income distribution, but changes are plausible.

Uncertainty around Change

There is a broad consensus that GDP (and therefore average income per person) will continue to rise over the long term. Although there is some uncertainty over the rate at which it will grow, this factor has been given a low rating.

There is greater uncertainty over the likely distribution of this income across the population. This will be driven by policy as well as market forces.

Potential Impact on Energy Needs and Behaviour

There is direct evidence that energy demand rises as incomes rise.[29] Higher incomes could also result in households being less driven by the need to save money and reduce waste. Using the OECD projections and assuming that the annual growth rate of per capita GDP is constant, this could result in a 52% increase in energy demand by 2050, other things equal. This uses the estimated UK long-term income elasticity of electricity demand of 0.56, which is based on aggregate UK energy demand between 1972 and 1994.[30]

This is an indicative estimate holding all other factors (including energy prices) constant. It assumes that the relationship between income and energy use stays constant at its historical level, and in practice the rise in demand due to higher incomes may be smaller as it doesn't take into account the other effects associated with rising incomes such as adoption of energy efficiency measures.

There is historical evidence from the UK that a rise in income is associated with an increase in energy use.

- One study estimated that the long-term income elasticity of UK energy demand was 0.56, and that the long-run price elasticity was -0.23. The study used data on aggregate energy demand between 1972 and 1994.[31]

- UK evidence cited in Whitmarsh et al (2011) also showed that those on higher incomes tend to use more energy domestically, and that this also carried over into transport.

There is some evidence that higher income consumers have a higher propensity to adopt energy efficient technologies.

A literature review found that attitudes to adopting energy efficiency measures vary by income, with those on higher incomes more willing to accept technical measures to raise energy efficiency[32]. The same study found that higher income households were likely to have a higher appliance turnover rate, raising the likelihood that older, less energy efficient, appliances were replaced.

The literature review did not address the question of whether lower appliance turnover was the result of lower absolute incomes, or whether it was affected by a household's position in the income distribution (i.e. relative incomes). This is important when assessing the future impact on energy behaviour as incomes continue to rise. We did not find any evidence distinguishing the impact on energy behaviour of households' position in the income distribution from the impact of their absolute income.

Lower income consumers have a higher propensity to be fuel poor, and may under-heat their homes.

A study by Hirsch, Preston and White (2011)[33] found that UK households with a relatively high proportion of income spent on fuel tend to be on low incomes[34]. The authors reported that households with incomes below £6,000 per annum were particularly likely to find their bills a financial burden, to reduce heating in the last year and to experience homes that were colder than they wanted in the previous winter. For over two million households who are not in the fuel poverty class, fuel still represents a relatively large proportion of their incomes.

A review of the demand response literature by Frontier Economics and Sustainability First[35] found that the limited evidence available (all from the USA) showed that low-income consumers did respond to economic incentives to shift their demand, but was mixed on whether their responses were smaller or no different from the average.

One demand response trial in the USA[36] found that household responses to technology aimed at enabling them to shift their demand varied by income. Low-income participants responded less than average to a web portal where they could access a breakdown of their consumption (showing an average peak demand reduction of 13% compared to 14% for those on higher incomes) and an in-home energy display (average peak demand reduction of 5% compared to 14% for participants on higher incomes). In contrast, they responded more than average to a smart thermostat which allowed them to automate their response to different tariff periods, reducing peak demand by 48% on average compared to 33% for those on higher incomes.

The case study of solar panels shows that uptake was highest among high income consumers, suggesting that the upfront capital cost constraint was important.

Related Factors

This external factor covers the following secondary factors:

- Disposable income growth and distribution
- Economic decision-making

This external factor has a strong relationship to these other key external factors:

- Fuel Prices
- Housing Tenure
- Household Size

Case Study 1: Recession and Energy Attitudes

Image courtesy of Ged Carroll

Relevant External Factor: Income

Economic hardship may reduce the priority consumers attach to environmental and energy issues. *UK evidence shows that energy and environment are regarded as lower priorities following the recent recession (Platchkov et al., 2011). However, this has not resulted in the expected change in behaviour. Self-reported energy-saving behaviour increased following the start of the recession, and this could have been motivated by the aim to save money.*

Evidence

UK survey evidence shows that, between 2006 and 2010, households became more preoccupied with economic issues such as unemployment and attached a lower priority to energy issues.[37] This suggests that worsening economic conditions can have a knock-on effect on attitudes to energy and the environment – 10.4% of respondents viewed energy as a priority for the UK in 2006, falling to 7.9% in 2010. Surveys by Ipsos MORI and Eurobarometer showed similar shifts in attitudes in the UK, for example with the share of UK Eurobarometer respondents naming climate change as the most serious global issue falling from 57% to 46% between 2008 and 2009. [38] At the same time, the share naming the global economic downturn as the most important problem more than doubled.

This change in attitudes did not translate into a reduction in energy-saving behaviour. UK evidence on self-reported behaviour change over the same period shows that the proportion of households doing “quite a number of things” or “lots of things” to lower their emissions and energy use has risen, from 19% in 2008 to 38% in 2009.[39] While this may at first appear to contradict the change in attitudes, research has consistently shown that energy attitudes do not directly define energy behaviour. In any case, the apparent contradiction could be consistent with households trying to reduce their bills by saving energy as a result of the recession. For example, research by the EST (2010) found that 65% of consumers were more interested in saving energy because of the recession. [40] It may also be that while energy issues have become relatively less important than previously when compared with economic issues, they have not becomes less important in absolute terms.

Attitudes to energy may also be affected by how energy policies are presented. A survey of 3,000 UK individuals in 2009 looked at three options for framing the policy to increase the proportion of renewable energy to 15% by 2020. It found that framing the policy in terms of creating new economic opportunities resulted in the least support, compared to framing in terms of energy security or climate change.[41] This was despite the evidence that consumers are motivated by economic drivers, and that economic framing of energy policy has been used by policymakers during the recent recession.

2.4.5 Cost of Low Carbon Technologies

Expected change to 2050	**HIGH**
Uncertainty of change	**HIGH**
Impact on Energy Needs and Behaviour	**HIGH**
Overall Impact	**HIGH**

PRP stock image

The absolute and relative (to conventional alternatives) costs of low-carbon and smart technologies, in synergy with the other economic factors, could also influence consumer purchasing decisions and perceptions of affordability. This factor is related to technological innovation.

Overall Impact

The cost of low carbon technologies has been included as an external factor as advances in technology are happening at a rapid rate, therefore affecting cost and the consumer response to them. As technologies become cheaper, more consumers will be able to afford them.

Expected Change to 2050

There are expected to be significant changes in the costs of low-carbon technologies out to 2050. For example, DECC's 2050 pathways model[42] estimates the following capital cost changes to 2050 relative to central 2010 estimates:

- a reduction of 39% for a 2.5 kW solar PV source;
- a reduction of 27% for air-source heat pumps;
- and a reduction of 9% for ground-source heat pump.

On top of the underlying change in technical costs, grants, subsidies and taxes could also impact on the prices faced by consumers.

Uncertainty around Change

The range of projections is wide for both capital and operating costs for a number of key low-carbon technologies so again this is rated as high. For many technologies, the range of forecasts includes both rising and falling costs to 2050 depending on the scenario. For example, in DECC's scenarios, there is a range of:

- -88% to 53% (central estimate -39%) for a 2.5kW solar PV source; and
- -50% to 17% for air-source heat pumps and -33% to 36% for ground-source heat pumps.

ESME scenarios suggest that meeting climate targets in the most cost-effective way will involve using technologies with higher upfront costs and lower running costs in the heating sector. For example in the ETI's core 'Director's Cut' scenario, around 40% of domestic and commercial space heat and hot water demand is produced by heat pumps by 2050. Less capital-intense technologies such as gas boilers also continue to play a role.[43]

The level of future grants, subsidies and taxes is also subject to uncertainty.

Potential Impact on Energy Needs and Behaviour

Falling prices of smart and low-carbon technologies relative to the conventional alternatives are expected to result in increased uptake, therefore having a high impact overall.

Our case study on the take-up of gas in Northern Ireland shows that factors other than cost can affect uptake. On the other hand, our case study on solar panels illustrates the importance of cost as a factor in uptake. In this case, consumer uptake of solar panels responded strongly to the introduction of a subsidy on solar panels.

In addition, high absolute costs of low-carbon technologies are likely to reduce uptake levels and therefore turnover rates in the existing stock of appliances.

Cost structures featuring high initial investments could potentially put consumers off adoption of smart or low-carbon technologies. Survey evidence on adoption of four energy-efficiency measures (including loft insulation, heating controls, energy-efficient lighting and condensing boilers) and four renewable technologies (micro-wind turbines, wood-burning stoves, solar thermal water heating and solar photovoltaic) found a range of reasons for households deciding not to adopt them. [44] These barriers to adoption included capital costs and perceived costs outweighing energy savings.

The cost of smart energy services, relative to the conventional alternatives, is likely to have a major impact on their uptake. Focus group participants in the BarEnergy project[45] stated that higher costs associated with energy-efficient appliances were one of the main barriers to adoption.

Another survey found that technologies being unlikely to last long enough to pay back the initial cost were amongst the reasons households chose not to adopt energy-efficiency measures and renewable technologies. [46]

There is also evidence that consumers may use high discount rates when making purchasing decisions – e.g. Meier (1983), found 40% of consumers behaved as though they had discount rates above 60% when looking at purchases of energy-efficient fridges. The higher the discount rate, the more consumers will favour technologies with lower capital costs and higher operating costs. For example, with a 10% discount rate the CCC finds that the cost of low carbon heat technologies increases to £4.8bn (from £1.2bn using the social discount rate). [47] [48]

Related Factors

This external factor has a strong relationship to these other key external factors:

- Income
- Fuel Prices
- Technological Progress
- Energy Performance Labels

Case Study 2: Impacts of Cost Structures – Solar Panels

PRP stock image

Relevant External Factor: Cost of Low Carbon Technology

Uptake of solar panels is concentrated among less capital-constrained households*. Following the introduction of the Feed-in Tariff (FiT), solar panels offered investment returns of 6-7% tax-free (Energy Saving Trust, 2011), and recent analysis shows that the number of installations has been higher in more affluent households with higher energy consumption (DECC, 2012). This is to be expected given the capital-intensity of the technology.*

Evidence

Domestic energy technologies are often capital-intensive and this can have a major influence on the rate and pattern of up-take by consumers. In particular, consumers can be averse to up-front spending even when the potential returns are high – either as a result of financing constraints, a lack of information or giving less weight to benefits that occur further into the future.

The introduction of high subsidies for photovoltaic (PV) solar panels following the introduction of the Feed-In Tariff (FIT) in 2010 made solar panels available, for the first time, as financially viable investment for many domestic consumers. A typical 3kWp domestic system cost around £10,000 and could generate savings and income of £670[49] per year at current prices - with higher savings if electricity prices rise. Investment in PV therefore offered an expected return of at least 6-7% tax-free.

Between April 2010 and the end of 2011, over 140,000 Solar PV installation had taken place. A recent report by DECC[50] shows some of the key patterns of consumer up-take of PV panels since the introduction of the FIT. It finds that the number of installations was higher in:

- more affluent, higher energy-consuming households;
- areas with lower mains gas coverage;
- rural areas;
- areas where the average age is above 40; and
- areas where educational deprivation is low.

There are a number of possible explanations behind these patterns. However, the concentration of installations in higher income and middle-aged groups is consistent with the theory that financial constraints are a major barrier to the up-take of capital-intense technologies. Higher take-up among more affluent households could also be the result of these households being more likely to own their own homes and therefore being more able to make changes to their home such as adopting solar PV. Similarly, more affluent households may be more likely to live in a house amenable to solar PV installation (e.g. being less likely to live in multi-residence buildings), and this may have increased uptake amongst this group.

The concentration of installations in areas with lower gas coverage suggests those without conventional gas heating (e.g. those using electrical heating) may be more willing to adopt new technologies. This may reflect these consumers' desire to mitigate the higher energy costs associated with dwellings off the gas grid, or a motivation to be autonomous and resilient in terms of energy behaviour.

In response to the financing barrier, new businesses entered the market. These businesses charged home-owners nothing upfront in return for a share of the FIT revenues ("rent-your-roof" schemes). Many of these focused on multiple roofs (aggregator schemes) and they were excluded from the above analysis as householders were not making the installation choice in many cases (e.g. social housing schemes).

At the end of 2011 in England, 24% of all domestic PV installations were assumed to be owned by aggregators. The high take-up of aggregator and "rent-your-roof" schemes combined with reductions in technology costs resulted in DECC revising support levels ahead of schedule in order to limit the FIT scheme costs.

2.4.6 Fossil Fuel Prices

Expected change to 2050	**MEDIUM**	 PRP stock image
Uncertainty of change	**HIGH**	
Impact on Energy Needs and Behaviour	**HIGH**	
Overall Impact	**HIGH**	
Changes in domestic gas and oil prices may influence the affordability of heat and mobility provision from fossil fuels, leading to a shift in fuel source preference as well as an increased awareness of energy issues. Increases in the cost of both fossil fuel and electricity without a corresponding increase in income may lead to more sustainable and creative ways of reducing energy use.		

Overall Impact

The overall importance of pricing is likely to rise as the roll-out of smart meters and adoption of low-carbon technologies encourages new energy pricing structures, which may be packaged with other interventions to encourage behaviour change. As a result, the price of energy is likely to have a high impact on uptake and use of technologies.

Expected Change to 2050

In DECC's central scenario, domestic gas prices are expected to rise by 9% between now and 2050 and domestic oil prices are projected to rise by 14%.[51]

Wholesale fossil fuel prices are an input to ESME. In the Director's cut scenario, gas prices are assumed to rise significantly to 2050.[52]

Uncertainty around Change

Scenarios for gas prices range from a 17% fall to a 36% rise by 2050. Scenarios for oil prices range from a 26% fall to a 53% rise by 2050.[53]

However, other external factors may reduce the impact of price rises on demand. For example, GB domestic energy prices rose by 16% in real terms in 2008, but household gas and electricity demand increased in 2008 and winter 2008/9 as average temperatures were lower than in the previous three years.[54]

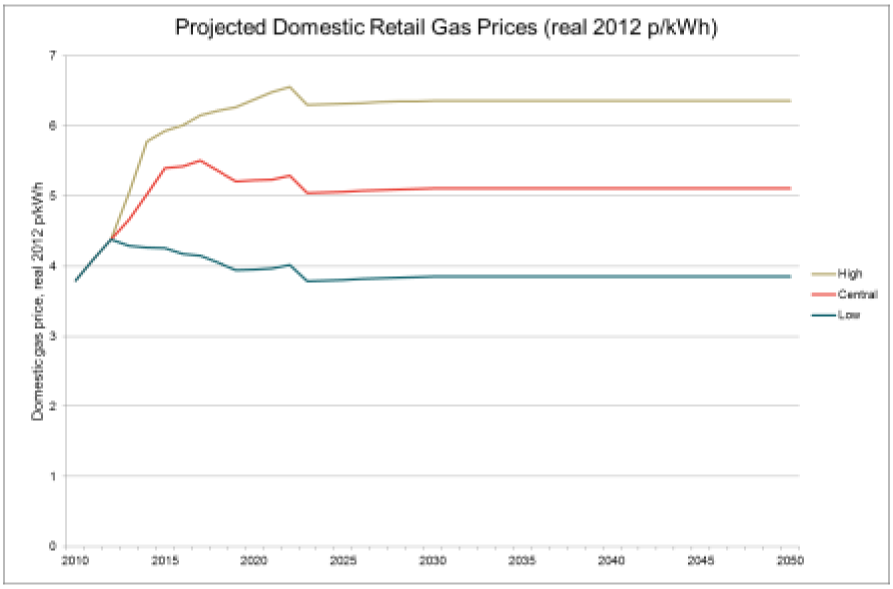

Figure 4: Projected domestic gas prices (Source: DECC and Department for Transport modelling)

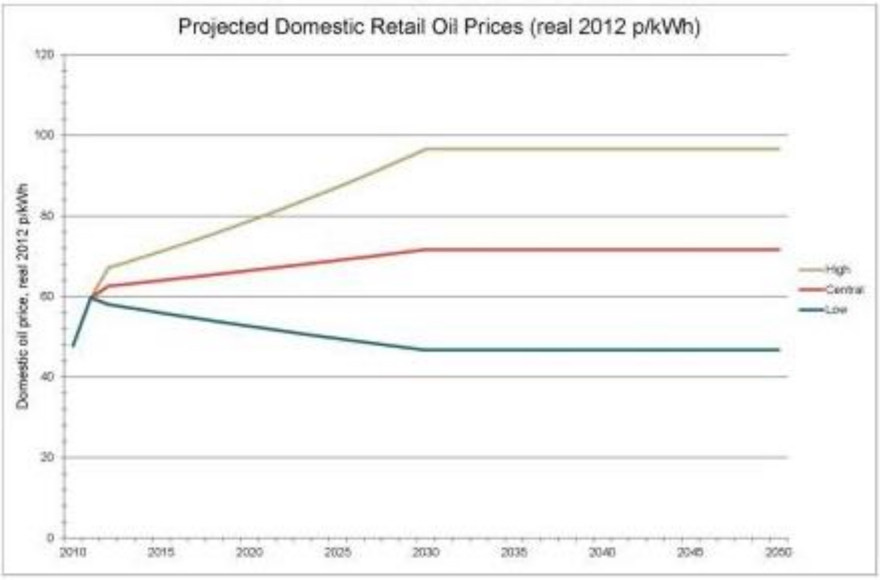

Figure 5: Projected domestic oil prices (Source: DECC and Department for Transport modelling)

Potential Impact on Energy Needs and Behaviours

Rising fuel prices may have two impacts:

- rising fuel prices in absolute terms may reduce demand; and
- rising costs of fossil fuels relative to low-carbon energy sources may result in substitution to low-carbon fuels.

One paper found that households may become more responsive to energy saving measures as energy prices increase.[55] The literature indicated that higher prices resulted in faster adoption of energy-efficient technologies and were correlated with increased spending on measures to save energy. This suggests that households may be driven by resource-related needs to save money, and that the behaviour resulting from this motivation is similar to the outcomes that might be expected from a personal desire to reduce wastage or be more self-sufficient.

This is supported by the case studies detailing the 1970s oil crisis and the 2000 gas price rises presented below, which shows that consumers responded to large fossil fuel price rises during the 1970s with a major switch towards gas central heating and away from more expensive and inefficient heating methods such as solid fuels, heating oil and town gas.[56]

However, DECC's scenarios also include the projection of lower oil and gas prices by 2050, which could result in substitution towards fossil fuels, so the overall impact expected to 2050 is uncertain.

There is also evidence of a rebound effect, where consumers allocate income saved from energy efficiency measures to increased appliance use.[57] Rebound effects can apply either directly (e.g. increasing the use of a new, more energy efficient, appliance) or indirectly (e.g. spending money saved from a more fuel efficient car on flights).[58] Heiskanen et al. (2009) also refer to positive rebound effects – for example where consumers reduce their energy demand and this results in them becoming more willing to support policies increasing energy costs.

Related Factors

This external factor has a strong relationship to these other key external factors:

- UK National Policy
- Technological Progress
- Diversity of Energy Generation
- Electrification
- Regulation of Energy Sector

Case Study 3: Fuel Prices – 1970s Oil Crisis

Image courtesy of Steve Wilson

Relevant External Factor: Fossil Fuel Prices

The oil crisis meant crude oil prices rose rapidly during the 1970s at the same time that demand for energy in homes also rose. While the retail prices of heating oil and solid fuels rose substantially during the 1970s, retail gas prices actually fell as North Sea gas was opened up. There was a major shift towards gas central heating in homes.

Evidence

Over the course of the 1970s the real price of crude oil increased tenfold, with major spikes in 1973 and 1979.[59] For domestic consumers the price changes were less severe with heating oil rising 102% in real terms over the decade and solid fuel[60] - the most used domestic fuel in 1970 - rising 47%.

Meanwhile, there was rapid expansion of North Sea natural gas during the 1970s and the National Transmission System (NTS) for gas was rolled out. The retail price of gas fell 44% over the decade (see Figure 6 below).

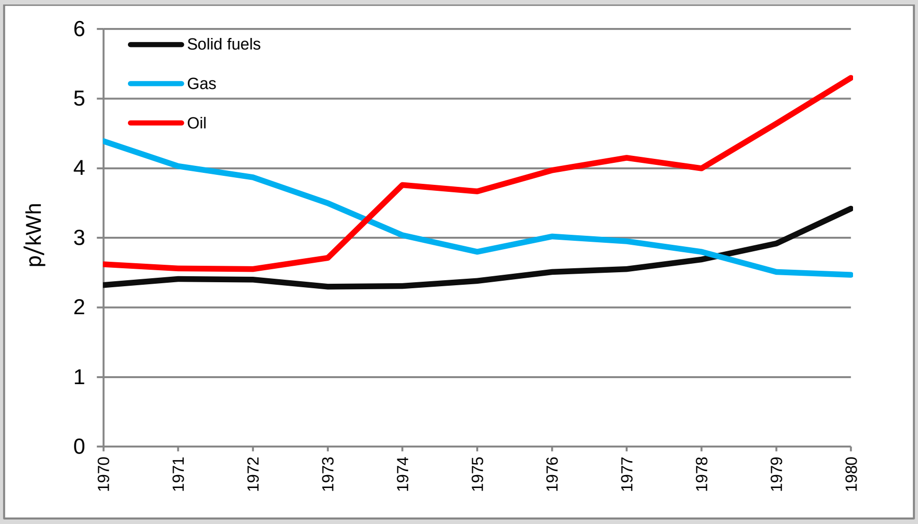

Figure 6: Retail fuel prices (p/kWh, 2009 prices, Source: DECC)

The consumer response during this period was a major switch towards natural gas-based central heating and away from more expensive and inefficient heating methods such as solid fuels, heating oil and town gas.[61]

The number of households with gas central heating rose from 2.0m in 1970 to 7.9m in 1980. Domestic use of natural gas rose from 7.0 MtOe in 1970 to 22.8 MtOe in 1980 whilst use of solid fuel fell from 38.3 MtOe to 28.8 MtOe.[62]

The average demand per person for final heating energy increased 11% during from 1970-1980, driven largely by increases in space heating demand which increased by 18%. The reasons for this are unclear but it may partly reflect natural gas lowering energy costs and/or central heating encouraging whole-house heating: between 1970 and 1980 the average internal temperature increased from 12.0 to 12.8 degrees. The average centrally-heated house was heated to 13.9 degrees in 1980. These estimates should be treated with caution given that internal temperatures were modelled and not measured.[63]

There is also some evidence of improving energy efficiency through loft insulation towards the end of the 1970s although the data is limited here.

In summary, the combination of oil crises and the falling costs of natural gas in the 1970s were associated with a major switch towards gas central heating. This allowed household demand to increase over the decade despite major increase in the price of oil and other fuels.

Case Study 4: Fuel Prices – 2000s gas price rises

Image courtesy of mxmstryo

Relevant External Factor: Fossil Fuel Prices

Despite large gas price rises over the 2000s, gas central heating has remained the dominant form of heating delivery. *Household energy demand does appear to have trended downwards over the decade although this may reflect energy efficiency policy measures rather than a price response.*

Evidence

Between 2000 and 2010 the wholesale gas prices more than doubled in real terms, including steep rises in 2004/5 and 2008/9. This has fed through into retail gas prices with real prices rising 104% in real terms between 2000 and 2009[64] (see Figure 7)

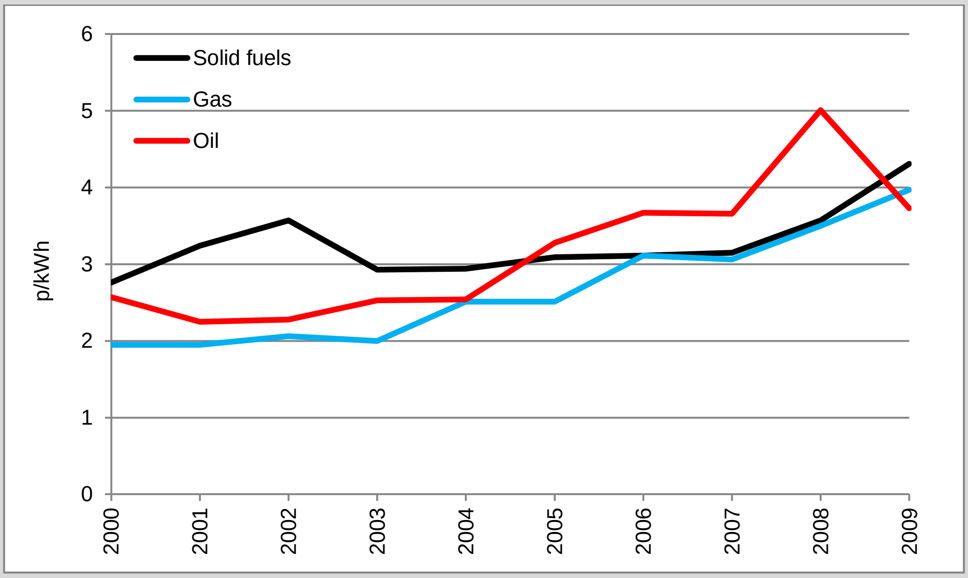

Figure 7: Retail fuel prices (p/kWh, 2009 prices, Source: DECC)

Figure 8 shows overall final energy demand dropping significantly in the second half of the decade, with demand per person falling over 15% between 2004 and 2009. However, demand rebounded again in 2010 during an abnormally cold 2010 (average winter temperatures were 4.3 degrees Celsius in 2010 compared to a 2000-2009 average of 6.9 degrees). Most of these changes were driven by changes in demand for space heating energy. Other sources of demand progressed broadly in line with their long-term trends.

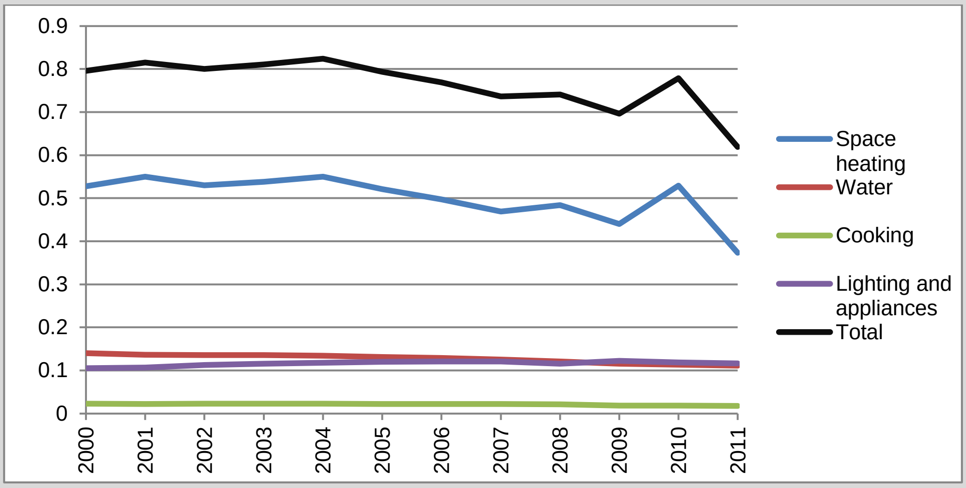

Figure 8: UK domestic energy demand by end use (tOe/person, Source: DECC)

The long-run price elasticity of domestic gas demand has been estimated to be around -0.3[65] (i.e. a 100% increase in price should reduce demand by 30% in the long-term). This suggests that price response was the driving force behind falls in demand over the decade. However, the economic downturn and the strengthening of government energy saving policies are also likely to have played a significant role.

Energy efficiency measures appear to be key means by which householders reduced consumption, with insulation and other heating efficiency measures responsible for demand reductions of over 10% between 2000 and 2007 (data for later years are not available).[66] How much of this is a direct response to price rather than government policy is unclear, however.

There is also evidence that some additional energy conservation may have taken place in latter half of the decade with households willing to tolerate lower internal temperatures: average internal temperatures fell from 18.5 degrees in 2005 to 16.9 in 2010.[66] However, over the same period average external winter temperatures fell from 7.1 to 4.3 degrees – so the fall in internal temperatures may reflect households not fully compensating for drops in external temperatures (e.g. allowing temperature to drop in some less used rooms), though the evidence on these behaviours is not available. As before, internal temperatures were estimated rather than measures, so are subject to uncertainty.

Despite prices rising faster for gas than other fuels (see Figure), gas continued to be the dominant form of home-heating delivery – with the percentage of households using gas central heating increasing from 70% to 84% over the decade.[66] However, there were some small increases in the domestic use of bioenergy and waste in homes.

The lack of fuel switching may reflect the 'lock-in' arising from the sunk costs of gas infrastructure (e.g. pipeline networks, boilers) and/or that cost-competitive alternatives have not materialised. In particular, solid fuel-based heating is relatively inefficient and less convenient than gas-based heating.

In summary, gas has been able to maintain its dominance as a provider of domestic heat despite major price rises over the course of the decade. Evidence on price elasticities suggests that price response is likely to have been the most significant driver in falling demand, while economic downturn and energy saving policies have also played a part.

2.4.7 Electricity Prices

Expected change to 2050	**HIGH**
Uncertainty of change	**HIGH**
Impact on Energy Needs and Behaviour	**HIGH**
Overall Impact	**HIGH**

Image courtesy of Alexis O'Connor

Changes in grid electricity prices may influence the affordability of heat and mobility provision from the national grid – cheaper electricity prices compared to fossil fuels could lead to a shift towards electrification not just in terms of heat but also mobility. Rises in electricity prices, on the other hand, similar to fossil fuel price increases, may lead to a general increased awareness of energy issues.

Overall Impact

As with fossil fuel prices, new energy pricing structures are likely to emerge, which may be packaged with other interventions to encourage behaviour change. As a result, the price of energy is likely to have a high impact on uptake and use of technologies.

Expected Change to 2050

In DECC's central scenario, domestic electricity prices are expected to increase by 36% by 2050 relative to the central 2013 price.[67] DECC also projects a doubling of electricity demand by 2050 in its 2050 pathways analysis.[68]

Uncertainty around Change

Scenarios for domestic electricity prices range from 28% to 44% growth from the central 2013 price by 2050.[69]

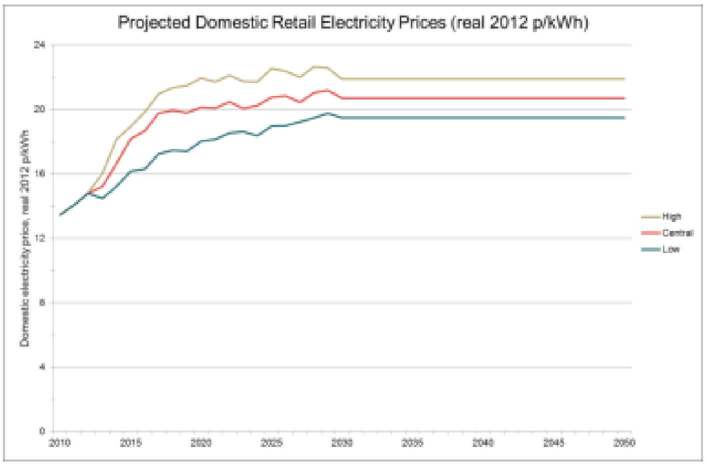

Figure 9: Projected domestic electricity prices (Source: DECC and Department for Transport modelling)

Potential Impact on Energy Needs and Behaviours

There is empirical evidence that higher electricity prices reduce energy demand – applying price elasticity of –0.23 [70] and 36% electricity price growth implies an 8% decrease in domestic electricity use to 2050, if price were the only factor driving demand.

A UK study found a long-run price elasticity of demand of -0.23, using data from 1972 to 1994 and controlling for other factors affecting demand such as income.[71] The US Department of Energy uses a long-run (20 year) elasticity of -0.31 for domestic demand and -0.25 for commercial demand.[72] US evidence from 2001-2008 suggested that elasticity had fallen since deregulation, to a range of -0.12 to -0.17.[73]

Another paper found from reviewing the literature that households may become more responsive to energy saving measures as energy prices increase.[74] The literature indicated that higher prices resulted in faster adoption of energy-efficient technologies and were correlated with increased spending on measures to save energy. This suggests that households may be driven by resource-related needs to save money, and that the behaviour resulting from this motivation is similar to the outcomes that might be expected from a personal desire to reduce wastage or be more self-sufficient.

For example, estimated daily or weekend elasticities in a demand response pilot for domestic customers in California ranged from -0.027 to -0.054.[75] US evidence from the late 1970s to early 1980s found peak period demand elasticity ranged between 0 and -0.4.[76] The review also reported that estimated elasticities from a demand response programme in Australia were -0.3 to -0.38 in summer, and -0.47 in winter.

Studies in some countries have found relatively high short-term demand elasticities. The own price elasticity of demand estimated from trialling the Tempo tariff in France was estimated to be -0.79 on-peak and -0.18 off-peak.[77] Faruqui and Sergici (2010) also note similar elasticities found in Japan (-0.77 on-peak and -0.56 off-peak), with similar estimates for households with and without electric water-heating and on different rates) and Switzerland.

However, other external factors may reduce the impact of price rises on demand. For example, GB domestic energy prices rose by 16% in real terms in 2008, but household gas and electricity demand increased in 2008 and winter 2008/9 as average temperatures were lower than in the previous three years.[78]

A review of the international evidence for residential consumers showed that consumers respond to economic incentives to shift their demand away from peak periods. It also found that automation of appliances (for example by automating air conditioning units or electric heating) can boost this effect, resulting in the greatest and most persistent impacts.[79] This result could be because behaviour is driven by the burden of demand-shifting activities on households, suggesting that reducing the tasks required to shift demand will raise the response. Price incentives to shift demand may also result in new demand peaks being created after peak periods when prices return to the off-peak rate. This could be enhanced by appliances whose response is automated, for example an air conditioner may use a relatively large amount of energy to reduce indoor temperatures following a peak period.

The review also found that participants in demand response trials tended to save money on their bills during the trial; and that saving money frequently appeared as either a motivation for taking part, or a reason for satisfaction. The paper hypothesised that people may be more motivated by the desire to save money during difficult economic conditions (e.g. recession), but found little evidence that this had been tested in the context of demand response.

Focus group participants in one UK study stated that to make consumers alter their energy habits, an economic incentive would have to be introduced (e.g. tax) or the element of choice removed (i.e. compulsory behaviour change).[80] Survey evidence on UK consumers' attitudes to automation of household appliances to shift use away from peak periods[81] showed that, even when offered only a small economic incentive, some consumers still accepted changes to how their appliances operated. More than 20% agreed to interruption to their fridge or freezer's energy use for a 1% discount on their bill. In contrast, 11% agreed to a cap on the use of their cooker at peak times in return for the same discount. Different attitudes depending on the type of appliance could relate to quality of life needs. For example, households may be unwilling to accept automation where they don't have confidence in the technology – this was one of the concerns raised around smart fridges/freezers. Similarly, appliances used for entertainment (e.g. TVs, radios) could be less appropriate for smart use during peak periods than appliances such as washing machines, as the end demand (e.g. watching a TV programme vs. washing clothes) is time specific (although potentially becoming less so) and therefore shifting it would impact on quality of life. A survey of 393 Dutch households[82] found that, when reducing the environmental impact of their consumption, respondents would be more willing to pay to sustain their comfort, freedom and pleasure, than to accept a reduction in their quality of life.

In contrast to the empirical trial evidence, survey evidence from Ofgem's Consumer First Panel (which consists of 100 domestic energy consumers) showed that they mainly reacted negatively to time of use tariffs and had a limited understanding of their purpose[83]. Most felt that the changes required of them involved too much effort. However, there is evidence of a rebound effect, where consumers allocate income saved from energy efficiency measures to increased appliance use.[84]

Rebound effects can apply either directly (e.g. increasing the use of a new, more energy efficient, appliance) or indirectly (e.g. spending money saved from a more fuel efficient car on flights).[85]

Ockwell (2008) cites research that suggests that direct rebound effects for domestic energy services are likely to be under 30% in OECD countries, while the evidence on indirect effects is limited. Heiskanen et al (2009) report that direct rebound effects for lighting tend to be around 10%.[86]

Heiskanen et al (2009) also refer to positive rebound effects – for example where consumers reduce their energy demand and this results in them becoming more willing to support policies increasing energy costs.

Lastly, there is evidence that economic incentives alone are not always effective. Economic drivers could also be made less effective if households are confused over how to realise economic benefits. For example, complexity around selling electricity from micro-generation back to the grid was one of the reasons found for households deciding not to adopt renewable technologies such as solar PV.[87]

Non-economic aspects are central to the impact of pricing on behaviour. For example, there is evidence that providing information on how consumers can change their behaviour to take advantage of time of use pricing incentives can enhance the results of introducing economic incentives. The Frontier and Sustainability First review found that interventions that combined economic incentives with non-economic incentives (such as in-home displays) delivered an incremental impact compared to using economic incentives alone.

This finding is supported by a separate review which found that transparency about energy costs (for example informative energy bills and energy efficiency labels) is positively correlated with energy-saving behaviour.[88] Similarly, a meta-study of smart metering, energy feedback and dynamic pricing pilots[89] found that communications techniques are central to successful demand response. Good communication ensured consumers were sufficiently educated and prepared for the introduction of economic incentives, for example by providing energy conservation or load -shifting tips. This evidence suggests that interventions should not be considered in isolation.

In addition, the importance of financial incentives relative to other motivations can be influenced by campaigns. For example, the Black Balloons campaign to demonstrate the link between climate change and energy use and encourage lower energy use resulted in those citing a motivation for saving money dropping from 76% to 56%, while the proportion citing a motivation for saving energy increased from 34% to 70%.[90]

Related Factors

This external factor has a strong relationship to these other key external factors:

- UK National Policy
- Technological Progress
- Diversity of Energy Generation
- Electrification
- Regulation of Energy Sector

2.4.8 Housing Tenure

Expected change to 2050	**LOW**	
Uncertainty of change	**HIGH**	
Impact on Energy Needs and Behaviour	**MEDIUM**	
Overall Impact	**MEDIUM**	*PRP stock image*
Changes in the level of housing ownership may influence consumer purchasing decisions and require a radically different approach in terms of the solution scenarios for market incentivisation and consumer engagement. If there is a shift towards ownership, then the impact of retrofit and intervention on property value may become significant. If there is a shift towards a rental market, tenant engagement becomes a priority issue, the role of green leases may be instrumental and the value of the retrofit may be driven by rental value, and the operational benefits to the tenants may become a bigger hook for the market.		

Overall Impact

This is likely to be of continuing importance as housing remains split between rented and owner-occupied properties. Changes to the balance of rented and non-rented properties over time could alter overall uptake and use of energy technologies.

Expected Change to 2050

Tenure has changed substantially in the past twenty years. Between 1993 and 2010, outright ownership in England increased from 25% to 34% of households, ownership with a mortgage decreased from 43% to 35%, private renting increased from 7% to 12% and council tenancy decreased from 22% to around 8%.[91]

Between 2012 and 2025, a small change in ownership (from 64% in 2012 to 65% by 2025) is expected in England, which is projected to continue to be roughly evenly split between households with mortgages and households without. Private renting is projected to stay stable at around 18% over the same period, while social renting is expected to fall from 18% now to 16% by 2025.[92] These projections were taken from work for the Resolution Foundation and Shelter, and for policy reasons may have focused more on scenarios where home ownership is not projected to rise. Comparable information for the UK as a whole is not available.

Uncertainty around Change

The projected change in renting relative to home ownership is sensitive to changes in income, house prices and policy over the same period. Stronger growth in the privately rented sector is projected where a weak economic recovery is assumed, and the proportion of privately rented households is projected to fall under the scenario of increasing social housing provision.[93]

Potential Impact on Energy Needs and Behaviours

Uptake and use of energy technologies may differ depending on whether a household is renting or owns their property. There is direct evidence that renting lowers uptake of energy-saving technologies, especially where there is a large upfront cost involved.[94] One source noted that landlords may pay for appliances while the tenant pays the electricity bills.[95] This could act as a disincentive to purchasing more energy efficient appliances as the benefits (e.g. reduced bills) would accrue to the tenant while the landlord bears the upfront cost.

Home owners may also be more likely to customise their homes (e.g. improving insulation) or adopt new appliances if they own their property. This could be because homeowners may be more likely to live in the property for longer and therefore are able to realise longer-term benefits from using particular energy technologies.

This is consistent with the theory that those in rented properties are less likely to invest in technologies that have high pay back periods.

However, DECC's 2012 consultation on electricity demand reduction outlines a range of policy options to address split incentives between landlords and tenants. In addition, there are provisions in the Energy Act 2011 for minimum energy efficiency standards to be introduced for privately rented properties from 2018.[96] This suggests that the differences in energy behaviour between renters and homeowners may decrease over time.

A literature review found a range of evidence that renting lowers uptake of energy-saving technologies, due to it being difficult for landlords to realise the benefits of investing in the technologies. This was found to be the case particularly for technologies involving a large upfront cost, such as thermal insulation.[97]

Related Factors

This external factor covers the following secondary factors:

- Costs of the welfare state

This external factor has a strong relationship to these other key external factors:

- Income
- Aging Population
- Household Size

2.4.9 Aging Population

Expected change to 2050	**HIGH**
Uncertainty of change	**LOW**
Impact on Energy Needs and Behaviour	**HIGH**
Overall Impact	**HIGH**

PRP stock image

The increasing average age of the population will impact on general consumer preferences and social norms, as well as the service requirements for heat and mobility. This factor is also related to income and the affordability of energy and technology.

Overall Impact

The age profile of the population is likely to have an impact on energy behaviour. Most evidence indicates that older populations are more likely to take up energy-saving and renewable measures

Expected Change to 2050

The share of the UK population over 65 is expected to grow from 17% in 2010 to 27% by 2050.[98]

The population under 16 is projected to decrease from 19% to 18% over the same period.

Uncertainty around Change

The ONS projects a mean absolute error of 2-2.5% for its projections to 2030. Projections after 2035 face greater uncertainty.

Historically, the largest differences between actual and projected populations have been for the youngest and oldest age groups.[99]

Potential Impact on Energy Needs and Behaviour

Changing age structures could have two contrasting impacts on energy use:

- demand for energy-efficient and renewable technologies is likely to increase owing to the rise in the population over 65;
- domestic energy needs may rise, due to a greater proportion of the population being retired.

A 2008 UK study conducted by the Open University, based on an online questionnaire and in-depth telephone interviews, found that older, middle socio-economic class consumers are more likely to take up energy efficiency measures. [100] Additionally, a significant proportion of renewable adopters were retired. The likelihood of adopting renewable systems was found to be lower if children under 16 years live in the house. The respondents to this survey were mainly environmentally concerned, 'green' consumers.[101]

Older middle income groups have also shown a higher propensity to take up renewable technologies. A recent report by DECC finds that the number of installations in PV panels was higher in areas where the average was above 40 in the period April 2010 to end 2011.[102] There is evidence that older people are more likely to adopt energy efficient and renewable technologies, while adoption is lower for households with children under 16.[103, 104]

Potential flexibility over the time of day when consumers use energy may increase, if consumers are at home more and therefore have a greater choice over when they can use their appliances.

In contrast, limited evidence suggests that households with younger occupants may have a higher propensity to shift their demand for energy across time. An Irish study of the impact of electricity smart metering on overall and peak electricity usage found that households with children under the age of 15 showed greater reductions in peak electricity demand than average: 10.7% compared to 6.5%. Feedback in focus groups indicated that this was driven by initiatives at schools.[105]

The Energy Demand Research Project also found that school education can not only increase the knowledge and understanding of pupils but also provide a means of influencing the behaviour of parents.[106]

A US study of the energy impacts of residential real-time pricing, found that older households were less likely to be high responders to high-price notifications.[107]

In a study of a DSR trial in the US, older participants responded less than average to the web portal and in home displays, and more than average to the smart thermostat. [108]

A study British Columbia and Newfoundland and Labrador pilots of real time displays found than older people saved less energy than the average population in response to the pilot.[109]

The literature indicates that age may affect attitudes and beliefs about energy efficiency measures, but the evidence is mixed.

A Swedish survey indicated that younger people have a better knowledge about energy efficiency, while a US survey found that those who save energy are likely to be older.[110]

However, these results may be because older people could already do more to reduce their energy demand, leaving less space for further reduction. This could help to explain some of the conflicting evidence on age effects on attitudes and behaviour.

An analysis of a Government led awareness and persuasion campaign in Ireland found that younger age groups (up to age 34) are substantially less likely to have a high interest in energy efficiency than the general sample population. [111]

In theory, an aging population could reduce the need for mobility, e.g. owing to retired people not having to commute to work. However, there might also be increased need for energy to meet mobility needs, e.g. more journeys done by car rather than walking.

However, with all this evidence, it is difficult to separate out the impact of age from other factors, such as income or household size.

We also note that it is not clear from the evidence whether the observed effects are due to aging or a cohort effect, i.e. the particular life experiences and current situation of those who are elderly today. The impact of ageing could be smaller if the evidence also reflects a cohort effect.

Related Factors

This external factor covers the following secondary factors:

- Demographics
- Extent people are at home

This external factor has a strong relationship to these other key external factors:

- Income
- Housing Tenure
- Household Size

2.4.10 Household Size

Expected change to 2050	**HIGH**	 PRP stock image
Uncertainty of change	**MEDIUM**	
Impact on Energy Needs and Behaviour	**MEDIUM**	
Overall Impact	**MEDIUM**	
Changing average household sizes, and the rise of single-person households will impact on housing demand, occupancy and energy usage patterns, and the shift towards or away from family-oriented needs, motivations, rationale and behaviour.		

Overall Impact

It is estimated that the combination of an increasing population and a decrease in household size could lead to a 30% increase in household numbers from 26 million in 2009 to 30 million in 2020 and 33 million in 2030.[44] The combined effect of a rising UK population and decreasing household size could increase emissions from buildings by 20 $MtCO_2$ by 2030.[112 113]

Expected Change to 2050

Household size has been decreasing for the last 150 years[114] and is expected to fall from 2.33 in 2010 to 2.16 in 2033, driven by a projected increase in the number of single person households. [115] It is estimated that the combination of an increasing population and a decrease in household size could lead to a 30% increase in household numbers from 26 million in 2009 to 30 million in 2020 and 33 million in 2030[44].

A key driver of this projected change is an increase in the number of single-person households, which will account for two thirds of the increase in households.[116] 18% of the population is projected to live in single-person households by 2031 (compared to 14% in 2008), of which 42% will be aged over 65.[117]

Uncertainty around Change

Household size projections vary by up to 7.5%. This is driven by differences in underlying assumptions on levels of fertility, life expectancy and migration.[118]

There is uncertainty over the future prevalence of multi-generational households.

Potential Impact on Energy Needs and Behaviour

Small households are more likely to spend a high proportion of their income on energy. [119] Through increasing the propensity to be fuel poor, increased one-person households could raise the driver to save money or for new polices in this area.

The evidence on how household size affects adoption of energy efficient and renewable technologies is mixed. There is UK evidence that larger households are less likely to shift demand in response to time of use tariffs and that smaller households saved more energy when trialling smart technologies.[120]

However, international evidence on the impact of household size on energy saving is mixed.[121, 122]

Results from a Canadian study based on household interviews show that households with 2-4 members show more energy saving activity than other sizes.

Another older study based on US data found that larger households invest less in energy saving.[123]

An econometric analysis based upon US data from 1975 finds that there is a negative impact of household size on energy-saving expenditures.[124]

Evidence indicates that being retired and in a small household (1-2 persons) are common characteristics of those who are high consumers of energy relative to income. [125]

Conversely, the Energy Demand Research project which presents the findings of large-scale government-sponsored trials of domestic energy demand technologies in the UK found that smaller households were more likely than larger households to shift consumption from the evening peak period in response to a time-of-use tariff.[126]

Lastly, the presence of pre-school children may increase energy use. A study which presents the results of the British Gas Green Streets project in the UK reported that the largest increase in energy use was in a household where a baby was born at the end of the baseline year. This sharp increase in energy use was driven by an adult and a baby being at home during the day, keeping the house warmer, using the washing machine more etc.[127]

Household composition also has an effect on the incidence of fuel poverty. An empirical study based on UK data finds that occupancy characteristics (number of children and household composition) are more important predictors of under consumption relative to an externally defined need than income. [128]

Related Factors

This external factor covers the following secondary factors:

- Household dynamics

This external factor has a strong relationship to these other key external factors:

- Income
- Housing Tenure
- Age

2.4.11 Education

Expected change to 2050	**HIGH**	 PRP stock image
Uncertainty of change	**LOW**	
Impact on Energy Needs and Behaviour	**MEDIUM**	
Overall Impact	**MEDIUM**	
Rising average levels of education and the level of energy efficiency awareness in schools and universities may greatly affect consumer perception to 2050, particularly if the shift in education happens now – today's students and schoolchildren will become the workforce and financial decision-makers in the run-up to 2050.		

Overall Impact

There is some evidence that the more highly educated are more likely to take up energy saving and renewable measures.

Expected Change to 2050

The number of graduates in the UK is projected to increase from 30% of the population aged 25-64 in 2005 to 40% by 2025.[129]

In 2000, 73% of females and males in the UK had attained at least secondary level education. This is projected to increase to 94% of females and 92% of males by 2050. This is a measure of the percentage of the population above the age of 15 who have attained at least secondary level education. [130]

Uncertainty around Change

Levels of education in the population are likely to continue to increase over time, following historical trends.

Potential Impact on Energy Needs and Behaviour

The impact of an increase in education levels on energy needs and behaviour could be high:

- the propensity to take up demand-side response could increase with greater educational attainment;
- demand for energy efficient and renewable technologies may increase; and
- initiatives in schools may result in behaviour change (e.g. demand shifting) driven by children.

There is some empirical evidence that those with higher levels of education are more likely to take up energy-saving behaviour[131] and adopt low-carbon technologies[132] (though the latter may be associated with more highly educated households being less capital-constrained).

A UK econometric study which considered loft insulation, wall insulation and double glazing in a sample of 7,000 households found higher levels of education associated with greater energy-saving activities.[133] This result has also been found in analyses of Irish and US households. [134135136]

A recent report by DECC found that the number of installations of PV panels was higher in areas where education deprivation was low in the period April 2010 to end 2011.[137]

In contrast, a Canadian study on the impact of conservation and German studies of the diffusion of energy-efficient lightbulbs found no statistically significant association between take up of energy-saving measures and education level.[138]

There is also some evidence that individuals with higher education respond more to time of use tariffs. In addition, there is evidence of educational initiatives in schools driving an increased responsiveness to time of use tariffs at home. [139]

In addition, in theory, higher education levels may be associated with greater awareness of global, national and local issues, and this may result in energy behaviour becoming more driven by motivations such as "saving the planet."

In a survey of British social attitudes, having degree level education was the most important factor in determining the level of individual environmental activity.[140]

In a separate study, Defra found that the segmented population group that held the most pro-environmental beliefs was also the most likely to have a degree. The two segments that showed the lowest level of environmental concern were more represented by those with low levels of qualifications.[141]

An Irish study compiled by the Commission for Energy Regulation looked at the impact of electricity smart metering initiatives on overall and peak electricity usage. Based on 5,028 participants in 2009-2010, the study found that households headed by individuals with a higher education or social grade achieved higher levels of reduction in overall and peak reduction in electricity demand. This was in part due to different initial demand levels meaning that the overall effect of education was quite limited.[142]

There is also evidence that low levels of education may be a barrier to engagement with smart systems. A UK study found that a lack of basic numeracy and literacy reduces the effectiveness of communication with smart systems. This effect is compounded by the likelihood that those with low levels of basic skills may be less likely to trust others (which was observed within 10% of those in socioeconomic group E in the study) and may tend to have a low opinion of their own ability to change anything.[143]

There is a possibility that evidence concerning the effect of education may in fact be capturing partly the impact of other factors such as intellectual ability on energy-using behaviours. Since intelligence levels change only slowly, if at all, over time the impact on needs and behaviour would be less than if education were the key factor.

Related Factors

This external factor covers the following secondary factors:

- Demographics
- Social Norms

This external factor has a strong relationship to these other key external factors:

- National Policy
- Income
- Age

2.4.12 Electrification

Expected change to 2050	**HIGH**	 PRP stock image
Uncertainty of change	**HIGH**	
Impact on Energy Needs and Behaviour	**HIGH**	
Overall Impact	**HIGH**	

The electrification of heat and transport on a mass scale throughout the 2020s and beyond, and consequently, the increase in overall electrical demand, will have an impact on the suitability and design of smart systems.

Overall Impact

The UK's power sector accounts for 27% of UK total emissions and, by 2050, emissions from the power sector need to be close to zero. Electricity is likely to be produced from three main low carbon sources: renewable energy (particularly onshore and offshore wind farms), a new generation of nuclear power stations and gas and coal-fired power stations fitted with CCS technology.

It has been included as an external factor as it could have a significant impact on consumer behaviour through the use of different technologies in the home, which use more electricity. The different technologies could also use less electricity, although the number of electronics in the home is expected to increase.

Expected Change to 2050

By 2030, electricity supply will need to be almost completely decarbonised. Power will be generated largely from renewables, nuclear and fossil fuel stations fitted with CCS technology.

The UK government expects electrification of heat and transport to occur on mass market scale throughout the 2020s and beyond. To meet the 2050 climate targets, DECC projects a doubling of electricity demand by 2050.[144]

ESME scenarios suggest that electrification would be a very important part of meeting climate targets in the most cost-effective way. In the ETI's core scenario ('Director's cut'), around 60% of domestic and commercial space heat and hot water demand has been electrified by 2050.[145]

Uncertainty around Change

Electrification will be challenging and require large investment in infrastructure. £200 billion will need to be invested into the UK's energy sector in order to help with decarbonisation.[146]

Given these challenges, there is some uncertainty over the rate at which it will occur.

Potential Impact on Energy Needs and Behaviour

Electrically powered technologies such as heat pumps will entail a significant change for consumers, as they have very different technical and economic characteristics to existing dominant technologies, such as gas-fired boilers.

In many of DECC's scenarios for 2050, electrification of heat plays a very large role, with up to 100% penetration in domestic properties.[147]

In terms of this impact on electricity prices, however, costs to the consumer are much more significant. In 2020 the residential retail electricity price could be 25% higher.[148]

In 2011, *Ecotricity* launched the world's first electric car charging system at motorway service stations. A lack of charging facilities is one of the reasons why consumers do not buy more electric cars. These investments could encourage consumers to change their purchasing behaviours to favour electric vehicles.[149]

Electricity demand will increase, but if it is met by low-carbon electricity, it will not have an impact on emissions.

Related Factors

This external factor covers the following secondary factors:

- New infrastructure

This external factor has a strong relationship to these other key external factors:

- Cost of Low Carbon Technology
- Efficiency Improvements
- Diversity of Energy Generation
- Regulation of Energy Sector

Case Study 5: Natural Gas in Northern Ireland

Image courtesy of Nicolas de Camaret

Relevant External Factor: Electrification

The switch towards gas central heating in Northern Ireland from 1996 has shown that ***drivers for switching and switch rates differ across customer types****, as well as demonstrating the* ***importance of a credible long-term commitment where large up-front investments are required as part of a roll-out****. Reasons for switching included that gas is cleaner or more convenient than coal; that it was cheaper, and that customers were not offered a choice (e.g. those in social housing, which was an important driver of overall uptake of gas) (CCNI, 2000). A significant marketing and awareness campaign was needed to encourage customers to switch to natural gas from oil.*

Evidence

The natural gas industry in Northern Ireland has developed in a "radically different" way to the equivalent industries in GB and the Republic of Ireland.[150] Northern Ireland does not have access to viable natural gas fields of its own, and until the late-90s there was no infrastructure for the distribution of natural gas. Customers therefore did not have access to the product: instead, homes were historically heated with oil-fired boilers or solid fuel.

In 1996, following the construction of an interconnector between Scotland and Northern Ireland which facilitated a gas supply, Phoenix Natural Gas Limited (PNGL) began to roll out a network for the distribution of gas to industrial, commercial and domestic customers. The roll-out was supported by Government, which saw a number of benefits of natural gas relative to oil, including:

- natural gas was, in general, cheaper than oil, and was therefore expected to ease the high level of fuel poverty in NI (and at the very least would introduce competitive pressure to bring fuel bills down);[151]
- natural gas was a more environmentally friendly fuel; and
- natural gas allowed for better control of heating facilities in the home, and removed the need for large oil storage tanks in homes.

Given the expected price and convenience benefits over oil, customers were expected to switch to natural gas fairly rapidly. By 2011, natural gas had been made available to around 300,000 customers in Phoenix's licence area, and around half of those customers had actually taken the option to use gas (see Figure 10). The market is expected to continue to grow at around 8,000 new customers each year.

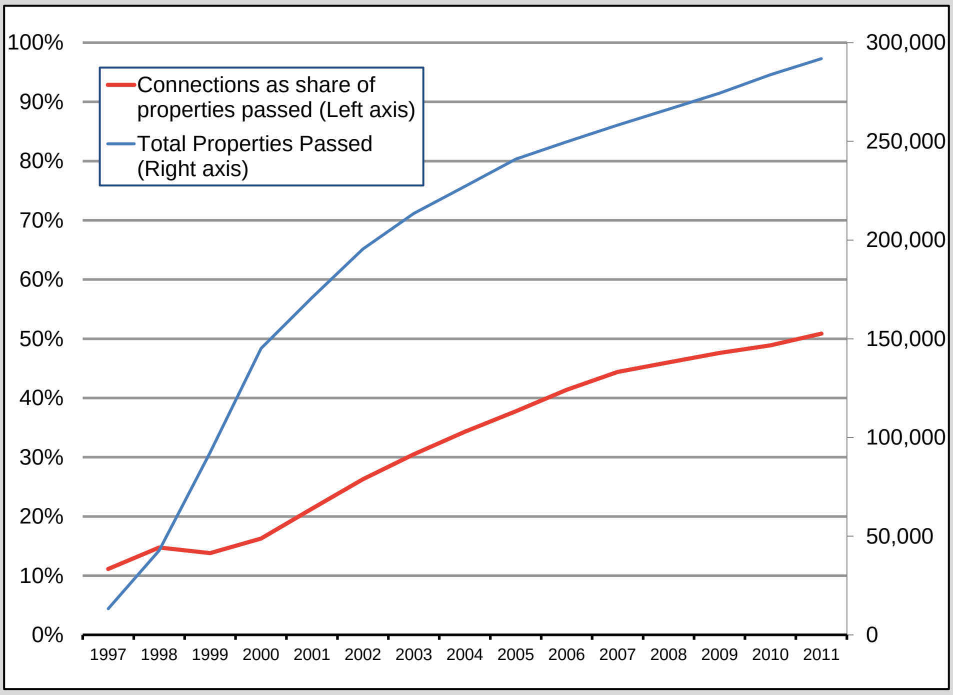

Figure 10: Connections and properties passed (*Source: PNGL)*

However, according to PNGL, oil remains the "fuel of choice" in Northern Ireland.[152] A significant marketing and awareness campaign was needed to encourage customers to switch to natural gas from oil, and regulated cost allowances continue to be made for this activity. Natural gas is still not available to large sections of Northern Ireland (market penetration is approximately 20% across Northern Ireland, compared to approximately 90% in GB).

In its recent review of Phoenix Natural Gas, the Competition Commission noted that, despite having been available since 1996, *"We were told…that natural gas was still a relatively new fuel to most Northern Ireland consumers and that there was a significant job to be done to 'sell' the fuel to the Northern Ireland public. The use of oil, we were told, was ingrained and there was a reluctance and mistrust of converting to natural gas, even apparently in homes where income might be well above the average and so the conversion costs would be more affordable."*[153]

A survey carried out in 2000 by the CCNI asked why customers had switched to gas, with the results shown in Figure 11.

Reason for switching	Percentage of respondants
Cleaner than coal and no fire to clean out	44%
No say in the matter/offered by NIHE/Housing Association	17%
Handier than coal – nothing to carry around	16%
More economical and cheaper	12%
Easier to use – automatic/instant	12%
For health reasons	6%
Other	41%

Figure 11: 2000 survey on gas customer switching in early phase of roll-out (Source: CCNI, "Gas Watch: Consumers' Experiences of Natural Gas in Northern Ireland", Autumn 2002)

The survey illustrates that, at least in the early phase of the roll-out, greater convenience drove switching behaviour rather than the expected economic gains. It suggests that households perceived significant benefits from switching to natural gas heating in terms of cleanliness, ease and immediacy, and health reasons. In contrast, an equivalent study published in 2012 found that *"The most popular reason given for converting homes to gas is that it is more economical. It appears that many consumers who have converted have picked up on the fact that natural gas is cheaper to use than home heating oil and that despite the large initial investment required, the payback period for investing in the conversion can be less than three years."*[154]

It is also clear that social housing authorities played an important role in ensuring take-up of the product in the early phase. *"Since natural gas was introduced to NI it has been the policy of the Northern Ireland Housing Executive (NIHE) and other social landlords to convert their properties to natural gas where possible. This social housing policy remains an important reason why many householders are gas users. In 2000, 17 per cent of gas users actually stated that they had no say in whether the house was converted to gas."*

2.4.13 Efficiency Improvements

Expected change to 2050	**HIGH**	 PRP stock image
Uncertainty of change	**LOW**	
Impact on Energy Needs and Behaviour	**HIGH**	
Overall Impact	**HIGH**	
The impact of advancements in smart system technology and their role in improving efficiency, including domestic appliances, retrofit products and microgeneration may lead to increased efficiency of production as well, leading to a decrease in the relative cost of technology and its subsequent affordability for consumers. On the other hand, stagnation in technological innovation would necessitate solution scenarios that rely on existing supply chains and technology to deliver heat and mobility to 2050 – with this constraint, how can targets be met?		

Overall Impact

Efficiency improvements directly impact consumer response and behaviour, in terms of both energy generation and appliance performance.

Expected Change to 2050

Increasing efficiency improvements are expected to 2050 and it is estimated that advances in technology will be able to reduce emissions significantly. The European Commission estimates that energy efficiency will have to improve by 20% across the EU in order to meet the 20% reduction in EU greenhouse gas emissions from 1990 levels.[155]

The UK is currently dependent on a centralised electricity generation system and the reasons for a move to decentralisation are to encourage the liberalisation of the electricity market and to reduce greenhouse gas emissions[1]. However, this means that a revamp of the whole physical and regulatory framework of the electricity network will be needed. Decentralisation is usually more efficient but it poses technical, political and institutional restrictions.

Uncertainty around Change

There is low uncertainty around the direction and degree of efficiency improvements expected to 2050. Energy efficiency tends to save money as well as reducing emissions. There are therefore strong incentives for it to occur.

Potential Impact on Energy Needs and Behaviour

The relationship between efficiency improvements and energy needs is likely to be highly significant. As well as reducing energy demand, increased energy efficiency could result in rebound effects[156], for example where consumers increase their use of an appliance following a rise in its energy efficiency.

Related Factors

This external factor covers the following secondary factors:

- New infrastructure
- Increased reliability

This external factor has a strong relationship to these other key external factors:

- UK National Policy
- Regulation of Energy Sector
- Energy Performance Labels

2.4.14 Diversity of Energy Supply

Expected change to 2050	**MEDIUM**
Uncertainty of change	**HIGH**
Impact on Energy Needs and Behaviour	**MEDIUM**
Overall Impact	**UNKNOWN**

PRP stock image

The role of low carbon technologies in meeting the Government's 2050 carbon targets, including large-scale renewables, microgeneration and the integration of EU energy markets will be an influence in the availability of green energy for the grid, which is of particular interest should there be a massive shift towards electrical demand.

Overall Impact

Rapid decarbonisation is required in the 2020s and 2030s and over the next decade the UK needs to continue reducing emissions from electricity generation through increasing the use of gas instead of coal and moving towards a diverse energy supply, although the overall use of has will probably need to decline. The reforms to the electricity market will be the most important step in making this happen.[157]

Expected Change to 2050

The UK needs to continue reducing emissions from electricity generation by moving away from fossil fuels and towards low-carbon generation such as renewables and nuclear. This could lead to either an increase or a decrease in the diversity of the supply of energy.

ESME scenarios suggest that meeting climate targets in the most cost-effective way would involve a reduction in diversity in the energy mix, with over 70% of generation being provided by nuclear by 2050 in the 'Director's Cut' scenario, and no significant role for micro-generation technologies such as solar PV.[158]

Uncertainty around Change

While the overall direction is clear, major uncertainties remain over both the most cost effective mix of technologies and the pace of transition. The UK Government is committed to ensuring that the low carbon technologies with the lowest costs will win the market share to protect the consumer.

While meeting carbon targets requires a move to low-carbon generation, DECC analysis and analysis by the European Climate Foundation has shown that a range of different supply mixes are possible, some of which are less diverse than others.[159]

As part of DECC's Carbon Plan, the three key scenarios highlight the range of pathways: higher renewables and energy efficiency; higher CCS and more bioenergy; higher nuclear and less energy efficiency.

As well as market forces, Government decisions will affect the diversity of energy supply.

The integration of EU energy markets will also be important and potentially could gain a better price for consumers; a European super-grid by 2050 would help control for intermittent generation and allow for the importation of energy from technologies such as concentrated solar power.[160] However, there is great uncertainty over whether this could be delivered.

Potential Impact on Energy Needs and Behaviour

The diversity of energy supply will affect consumers' exposure to supply interruptions and price spikes.

Lack of diversity will be experienced by consumers in terms of blackouts or problems with supply, and may lead to action to become more self-sufficient – for example by investing in micro-generation or energy storage.

DECC has recognised the role that communities could play in helping the Government reach the UK's challenging targets. The forthcoming Community Energy Strategy[161] is being developed with input from a range of communities.

For consumers, the costs of renewable energy technologies are uncertain but are expected to fall over time as supply chains develop, technical challenges are overcome and the cost of capital reduces with lower risk.

However, it remains unclear whether the diversity of energy supply will increase or decrease with the move to a low-carbon economy. If diversity increases, it may require great involvement on the part of the consumer to regulate their energy use in order to suit more intermittent supply.

Related Factors

This external factor covers the following secondary factors:

- New infrastructure
- Increased reliability

This external factor has a strong relationship to these other key external factors:

- EU Policy
- UK National Policy
- Fuel Prices
- Efficiency Improvements
- Electrification
- Regulation of Energy Sector

2.4.15 Regulation of Energy Sector

Expected change to 2050	**MEDIUM**	 Image courtesy of Chris Potter
Uncertainty of change	**MEDIUM**	
Impact on Energy Needs and Behaviour	**HIGH**	
Overall Impact	**HIGH**	
Independent regulation in controlling wholesale and retail markets and networks may be instrumental in maintaining the security of our energy supply and reducing carbon emissions. This reliability may consequently increase consumer trust and make acceptance of mass-scale retrofit solutions and smart system deployment more feasible.		

Overall Impact

Independent regulation of the gas and electricity markets has been a cornerstone of energy policy ever since privatisation was initiated in the 1980s. Competition has enabled greater efficiencies and lower consumer bills. However, the energy landscape is changing and the Government is testing whether the existing regulatory arrangements will be capable of meeting the challenges of the future.

Expected Change to 2050

The independent regulator is likely to continue to regulate wholesale and retail markets and networks, aiming to protect consumers, including through maintaining security of supply and reducing carbon emissions. While the aims are likely to remain constant, the exact nature of the regulation and the emphasis on different sub-goals may change over time.

Under the Energy Bill 2012, companies producing low-carbon energy would receive a higher price for their energy than for that produced in fossil fuel power plants but prices will not be set until summer 2013.

It is estimated that around £200 billion of investment will be needed by 2020 to meet these challenges and without policies to reduce demand, there is a risk that consumers will overpay for new electricity supply and lose out.[162]

Uncertainty around Change

There is some uncertainty over the change in regulation out to 2050. While the aims are likely to remain constant, it is not clear how the emphasis between sub-goals may change over time. Implementation methods are also subject to uncertainty.

The future direction of mandatory obligations on energy companies is unclear, however, energy companies highlight the "boom and bust" nature of previous supplier obligations and the regressive nature of ECO where everyone contributes the same amount regardless of income or ability to benefit. It is, therefore, anticipated that future programmes may still focus on energy efficiency but use a different system for funding this.[163]

Ofgem[164] carried out an investigation into whether or not future security of supply can be delivered by the existing market arrangements over the coming decade. It identified a number of concerns with the current arrangements and concluded that significant action will be called for over the coming decades, given the unprecedented challenges facing the electricity and gas industries.

Potential Impact on Energy Needs and Behaviour

Since regulation directly affects the level and nature of the price signals sent to consumers, the impact on behaviour is likely to be high.

Regulation of the energy sector can affect consumers in a number of ways. For example, regulation of networks and wholesale markets affects the price faced by consumers. Regulation of the retail sector will affect the tariff types offered to consumers as well as the price.

Recent regulatory interventions in Europe, including those in the proposed UK Electricity Market Reform, contain several elements aimed at 'nudging' energy users. These include the roll-out of smart meters, differentiated time-of-use tariffs, regulatory incentives for shifting the timing of energy consumption, and consumption data sharing at the community level.[165] However, progress seems to be at a national level with different systems at different stages of implementation across the member states.[166]

Recently, The Energy Companies Obligation (ECO) took over from the Carbon Emission Reduction Target and the Community Energy Saving Programme which ended in December 2012. It will replace CERT and CESP in early 2013. ECO will create a legal obligation on certain energy suppliers to improve the energy efficiency of domestic households, targeting the most vulnerable. However, despite significant investment on measures to contribute to the objectives set out in the Fuel Poverty Strategy, the number of households assessed to be in fuel poverty has not fallen in line with the targets.

The way energy companies are regulated (for example a shift for companies to provide services such as heat and entertainment as opposed to simply energy units) could also affect consumer interaction with energy providers by making them more actively engaged with their energy use.[167] For example, British Gas anticipates a move to an energy service model providing home infrastructure, potentially competing with new entrants to the market such as Google.[168] Scottish and Southern Energy already offer to households telecommunications services.[169] However, other stakeholders anticipate a focus remaining on energy-related services such as smart metering, retrofit installations and low energy appliances.[170]

Consumers face an array of tariffs and inconsistent information when choosing an energy supplier, particularly when they are not able to use online comparison sites, and Ofgem has proposed a radical shake up of the retail energy sector in more than a decade. This will enable consumers to better understand what is on offer and more easily choose the right supplier and best deal for them.

Related Factors

This external factor covers the following secondary factors:

- Energy efficiency standards

This external factor has a strong relationship to these other key external factors:

- UK National Policy
- Fuel Prices
- Diversity of Energy Generation

2.4.16 Energy Performance Labels

Expected change to 2050	**LOW**	
Uncertainty of change	**LOW**	
Impact on Energy Needs and Behaviour	**HIGH**	
Overall Impact	**MEDIUM**	*PRP stock image*
Energy performance labelling has an impact on consumer decision making and the potential to take the least efficient items off the market.		

Overall Impact

The UK Government anticipates that increased energy efficiency of products will reduce average household bills by £141 by 2020[171] and will play a key role in meeting carbon reduction targets. However, increases in the number of appliances in homes and in the size of certain products have the potential to undermine this reduction. In our understanding of product performance labels, this includes appliances and electronics, as well as whole house performance in terms of Energy Performance Labels (EPC).

The European Association of Home Appliance Manufacturers states that more than 188 million home appliances across Europe are more than 10 years old. Renewing these appliances represents a huge potential reduction in greenhouse gas emissions.[172]

Expected Change to 2050

Performance labelling is already under way via mandatory and voluntary schemes, although their impact may depend on the extent to which they are used to remove inefficient products from the market.

Uncertainty around Change

It is relatively certain that performance labels will have an increasing role in consumer decision-making.

Potential Impact on Energy Needs and Behaviour

Mandatory and voluntary product labelling is seen as an important influence upon consumer behaviours and decision-making as they are quite easy to understand and provide individuals with a simple heuristic to identify 'green' products.

However, the bigger effect of performance labels could be the ability to take the least efficient items off the market entirely, as with boilers.

An enhanced labelling scheme may allow for a reduction in energy use and change the behaviour of consumers to be more energy efficient when purchasing products. However, the trend in increasing the number of appliances in consumers' homes and size of these new appliances has the potential to undermine this effect.

The household sector currently accounts for around 32% of the UK's energy use and to meet Government targets, household emissions need to be reduced by 80% by 2050. The Government expects a significant proportion of these reductions to come from households using less electricity to power their appliances. The Energy Saving Trust has also argued that the current policy framework is not enough to meet energy reduction targets without a change in consumer behaviour.[173]

Compared to other markets, particularly the property market, consumers are relatively energy aware when buying appliances and stronger policy will only seek to enforce this. In only 11 per cent of cases consumers are not interested energy savings, although in 41 per cent of purchases the energy rating does not influence consumer decision-making and lack of awareness and understanding were common reasons for not using the performance label. In most cases, consumers found information about the product's energy use easily, but consumers had more difficulty finding running costs, reflecting the fact that the EU energy label does not give running costs in monetary terms despite this being the main reason consumers used the energy label when making their purchase.[174] Even more useful might be the additional running costs relative to appliances with the highest rating. Default options are powerful tools because, when consumers feel overwhelmed by choice or unable to make informed decisions, they will often assume that the default is preferable.

Interestingly, the National Measurement Office carried out a market study of compliance rates and found non-compliance in 30% of products displayed in stores, with non-compliance higher online.[175]

Related Factors

This external factor covers the following secondary factors:

- Energy efficiency standards
- Product standards
- Consumer protection

This external factor has a strong relationship to these other key external factors:

- EU Policy
- UK National Policy
- Cost of low carbon technologies
- Technological Progress

2.4.17 Building Regulations

Expected change to 2050	**HIGH**
Uncertainty of change	**LOW**
Impact on Energy Needs and Behaviour	**MEDIUM**
Overall Impact	**HIGH**

PRP stock image

Stricter Building Regulations for new (and, in theory, existing homes) may be instrumental in reducing domestic carbon emissions and meeting the UK's 2050 targets if coupled with strong enforcement and regulatory consistency.

Overall Impact

Improving efficiency within the domestic sector will make a significant contribution to meeting carbon targets and, while there have been recent emission reductions in the building sector, the main driver is likely to have been the recession rather than policy strengthening.

Regulation and minimum standards are likely to be successful in the housing sector, as there is significant regulatory capacity in this field following previous introduction of health and safety regulations. For example, the existing framework of building codes has evolved to involve measures which promote sustainable consumption.[176]

Expected Change to 2050

By 2030, the UK projects a stock of around 2-3 million new homes will be built to zero carbon. This is the result of regulation, which will require new homes from 2016 to be built to level 5 of the Code for Sustainable Homes, although the code itself may eventually become redundant.

Uncertainty around Change

Building Regulations will be subject to ongoing consultation, review and alteration.

Potential Impact on Energy Needs and Behaviour

Zero carbon homes will reduce consumers' energy use and reduce the emissions associated with this use.

However, the building regulations definition of 'zero carbon' does not include consumers' emissions from cooking and electrical appliances and these account for one-third to half of a home's total emissions so, whilst a home according to regulation may be zero carbon, consumer behaviour within it may not be zero carbon.

Research from the NHBC Foundation[177] shows that consumers are highly satisfied with energy-efficient new homes but are not informed or prepared for the lifestyle changes needed to live in zero carbon homes.[1] The research shows that, without strong government and industry intervention, homeowners could lose lose the benefits of some of the features and requirements of Code Level 6 zero carbon homes including airtightness and the absence of amenities such as power showers. They might, for example, leave windows open more than necessary for ventilation.

Related Factors

This external factor covers the following secondary factors:

- Planning Policy

This external factor has a strong relationship to these other key external factors:

- EU Policy
- UK National Policy
- Energy Performance Labels

2.4.18 Extreme Weather Events

Expected change to 2050	**MEDIUM**
Uncertainty of change	**MEDIUM**
Impact on Energy Needs and Behaviour	**HIGH**
Overall Impact	**MEDIUM**

PRP stock image

An increase in extreme weather events, such as changing rainfall patterns, leading to droughts, floods, storms and heavy snowfall may have an impact on energy generation, quality of life, heating and cooling requirements and consumer awareness of climate change. The increased intensity of extreme weather events may also have structural implications for certain technological solutions, as well as health and safety risks.

Overall Impact

The UK's climate is already changing and over the next 50 years the UK can expect higher temperatures, changing rainfall patterns, rising sea levels and more frequent extreme weather events ranging from droughts to floods.[178] These changes are expected to raise consumer awareness of the anthropogenic impact on climate change, while also impacting energy supply overall if extreme weather causes widespread disruption.

Expected Change to 2050

Over the next 50 years it is projected that the UK will experience changing rainfall patterns, rising sea levels and more frequent extreme weather events ranging from droughts, floods and potentially freezing winters.[179]

The extreme weather experienced in 2012 ranged from droughts to floods, hot to cold and was the second wettest summer since national records began in 1912. This weather pattern could become the norm for the UK.[180]

Uncertainty around Change

Scenarios for the rise of severe weather events and can be produced with some certainty around them.

Potential Impact on Energy Needs and Behaviour

The importance of extreme weather events in terms of influencing consumer behaviour is likely to increase as the UK's weather becomes more unpredictable over the next 50 years and consumers adapt their behaviour to combat these extremities. A rising incidence of severe weather events could increase supply interruptions. Consumers might respond in various ways, depending on how they interpret changes in climate and the extent to which they, or local buildings, are affected. Some may take action to become more self-sufficient – for example by investing in micro-generation or energy storage. Local risk of wind damage could have the opposite effect, while others might focus on the resilience of their home to storms and floods, rather than actions related to energy use.

The wider impact will depend on the extent to which people make the connection between UK weather and global climate change. If this connection is recognised, and householders accept that they can make a difference, this should prompt greater efforts to cut CO_2 emissions.

Rising sea levels or extreme weather events could substantially impact upon the resilience of local infrastructure such as power supply[3] and the adequate protection of vital energy supplies which could potentially impact thousands of consumers who will be left without power in their homes due to extreme weather events. This was especially evident in the floods of summer 2007 where 55,000 properties were flooded and 350,000 were left without mains water[1].

These floods raised concerns surrounding the protection of vital energy supplies and the resilience of substations to flooding and isolating consumers in their homes. 55,000 properties were flooded and left 350,000 without mains water[1]. The increase in extreme weather events over the next 50 years increases the likelihood of more consumers being left without power in the event of flooding and struggling to keep their homes cool in summer months.

Related Factors

This external factor covers the following secondary factors:

- Rising CO_2 levels
- Drought

This external factor has a strong relationship to these other key external factors:

- External Temperature

2.4.19 External Temperature

Expected change to 2050	**MEDIUM**
Uncertainty of change	**MEDIUM**
Impact on Energy Needs and Behaviour	**HIGH**
Overall Impact	**MEDIUM**

PRP stock image

Increasing external temperatures and subsequent changes to heating and cooling demand may lead to increased heating and cooling requirements and overheating risk. It would also tend to increase consumer awareness of climate change.

Overall Impact

The UK's climate is already changing and over the next 50 years the UK should expect higher temperatures.[181]

Expected Change to 2050

Over the next 50 years it is projected that the UK will experience higher temperatures and more frequent heatwaves.

Uncertainty around Change

Scenarios for the rise of external temperature can be produced with some certainty around them.

Potential Impact on Energy Needs and Behaviours

Changing temperatures could increase consumer demand for air conditioning and could reduce consumer demand for heating.[182] For example, consumers who are able to afford it could combat the increased temperatures through the installation of air conditioning, leading to an increase in energy demand in the summer and, consequently, household energy bills.[183]

The importance of extreme weather events in terms of influencing consumer behaviour is likely to increase as the UK's weather becomes more unpredictable over the next 50 years and consumers adapt their behaviour to combat these extremities. For example, consumers who are able to afford it could combat the increased temperatures through the installation of air conditioning during the summer months, leading to an increase in energy demand and, consequently, household energy bills.[184]

Boardman[185] suggests that the significant increase in Cooling Degree Days could lead to 29%-42% of homes having air conditioning by 2050 as well as the UK having increased summer heat-related deaths.[186] In August 2003, a heat wave caused 2,000 premature deaths in the UK alone and predictions suggest that heat-related deaths may increase in the UK by 540% by 2080, with older people the major victims.[187]

Analysis for DEFRA suggests that use of air conditioning by households could increase 17-100 fold by 2050.[188]

The potential need for residential air conditioning would be substantially reduced by construction and retrofit incorporating provision for passive cooling. This would include, for example, smart shading, high thermal mass, secure night ventilation and low incidental gains from appliances.

Related Factors

This external factor covers the following secondary factors:

- Speed of change of temperature
- Rising CO_2 levels
- Overheating from external temperature conditions
- Drought

This external factor has a strong relationship to these other key external factors:

- Severe Weather Events

2.5 Summary of External Factors

The following table, a summary of each of the external factor profiles is presented in Figure 11. The figure should be read with the following understanding:

- **Expected Change**: According to existing research, what is the level of likely change for each external factor between now and 2050?
- **Uncertainty of Change**: Does the existing research provide strong evidence that the external factor is likely to take a certain trajectory or are there a variety of projections?
- **Impacts on Needs/Behaviour**: Considering both the external factor as it exists in 2013 and the expected change to 2050, is the impact on consumer needs and behaviour expected to be high?
- **Overall Impact**: Taking into account the previous three categories, what is the overall impact of each external factor.

		Expected Change	Uncertainty of Change	Impact on Needs/Behaviour	Overall Impact
Political	EU policy	M	M	M	M
	National policy	H	H	H	H
	Local policy	M	H	H	H
Economic	Income	H	L	H	H
	Low carbon technology costs	H	H	H	H
	Fossil fuel prices	M	H	H	H
	Grid electricity prices	H	H	H	H
Social	Housing tenure	L	H	M	M
	Aging population	H	L	H	H
	Household size	H	M	M	M
	Education	H	L	M	M
Tech.	Electrification	H	H	H	H
	Efficiency improvements	H	L	H	H
	Diversity of energy supply	M	H	M	?
Legal	Energy sector regulation	M	M	H	H
	Energy performance labels	L	L	H	M
	Building Regulations	H	L	M	H
Env	Severe weather events	M	M	H	M
	External temperatures	M	M	H	M

Figure 11: Summary of external factors in terms of change and impact

As predicted, the existing literature and case studies suggest that all but one of the chosen top 18 external factors are expected to have medium or high overall impacts on consumer needs and behaviour, with over half expected to have a high impact.

Six of the group (income, age, education, technological progress, energy performance labels and building regulations) have a low uncertainty of change, meaning the evidence surrounding the expected change to 2050 is robust. This has helped form a solid basis for scenario development in the following section, and will be particularly useful in **WP5.5** in the development of solution scenarios.

3. Development of External Scenarios

Building on the analysis of factors in Section 2, the project team took on the challenge of developing scenarios to 2050 that illustrate how external factors could lead to different future worlds for which solution scenarios for heat would be developed. These scenarios are intended as a tool for examining a wide range of futures and are not intended to be predictive with any degree of certainty – the considerable timescale to 2050 makes this level of scenario planning speculative and imprecise.

The development of solution scenarios will be undertaken as part of WP5.5, which will start in May, 2013. The scenario development in this section will inform the development of these solutions, as well as feeding into their evaluation and characterisation. Specifically, they will help to identify which are the solution scenarios and smart energy systems that have the potential to successfully operate in a range of future worlds. Developing this understanding will allow this project to produce robust solutions that are resilient in the face of potential political, economic, social, technological, legal and environmental changes as the UK moves to a low-carbon economy 2050, while also identifying the uncertainties around these changes.

In this section we describe the assumptions used for scenario development, followed by an explanation of how the external factors vary across the four different scenarios. Finally, we describe the scenarios themselves and present a commentary on how these will impact on consumer requirements and the development of future solutions.

It is important to note that the developed scenarios are not intended to be predictive as identifications of equally likely futures. Rather they represent plausible futures, sometimes stretching to extremes, in order to help plan and evaluate plans and designs (particularly WP5.5's Solution Scenarios) against a range of different futures, defined primarily by varied external factors.

3.1 Methodology

3.1.1 Identification of External Factors and Assumptions

The development of scenarios was based on our understanding of the top external factors, identified earlier in this report, and their likely trajectories of change.

We sought to build on this understanding and identify the key relationships between external factors in order to develop future scenarios which identify potential future worlds and the obstacles likely to be faced with the introduction of a smart energy and heat system.

Members of the consortium met for a workshop to develop scenarios in mid-January. In developing these scenarios, the team agreed to the following assumptions.

- **Focus on varying factors that are likely to have the greatest impact, whether they have certain or uncertain trajectories.** The scenarios will not be able to encompass every possibility, but they should ensure that the main uncertainties around factors that will affect the success of solutions (in terms of consumer uptake and use) are captured.

- **Consistency with meeting the 2050 climate targets, and internal consistency and plausibility, in the context of meeting our climate goals**. Since this project is investigating smart solutions in the context of our 2050 climate goals, all of our scenarios assume that the 2050 climate targets are met.[189] To ensure that they are consistent with meeting these targets, our scenario development has been informed by the scenarios produced by the ETI's ESME model, DECC's Carbon Plan as well as those produced by the Committee on Climate Change.

- **A manageable number of scenarios**. For the scenarios to be useful in solution development, it is also important that we produce a manageable number, even if this means that other plausible states of the world may exist in the future that are not covered by these scenarios.

3.1.2 Choice of main factors to vary across scenarios

At the start of the workshop, consortium members were briefed on the top external factors and our key findings for each. Taking these findings and the above assumptions as a basis, the attendees were divided into sub-groups, and each group was tasked with considering the intersection of key themes or external factor groupings that were likely to have the greatest impact on consumer requirements and behaviour. Originally, the scenarios were framed in terms of ability and willingness for consumers to take up smart system solutions. However, following initial feedback from ETI, we noted a need to clarify and expand on how the external factors relate to the scenarios. We also made the implicit role of Government an explicit part of the framework. This led to the development of a three-dimensional matrix of three critical elements for the future uptake and usage of smart system solutions. These elements are as follows.

- **Technological progress** (impact of advancements in smart system technology and their role in improving efficiency, including domestic appliances, retrofit products and microgeneration may lead to increased efficiency of production as well as leading to a decrease in the relative cost of technology and their subsequent affordability for consumers).
- **Government involvement** (related to the level of government involvement in pushing the low carbon agenda and driving the take-up of smart system solutions).
- **Consumer willingness** (to take up and use smart solutions, by considering willingness, more accurate judgments can be made on the overall impact on behaviour that is likely to result from each change in external factor).

It is important to note that these three key themes are not necessarily external factors themselves, rather they are *themes* in which grouped external factors are aligned, such that when the key external factors are varied, a similar change within the themes is expected. This is particularly key to note with regards to the **consumer willingness** axis – as the literature suggests, many of the key external factors (such as age, tenure and education) have a clear link to willingness to take up certain smart energy technologies and solutions.

Both technological progress and government involvement are considered as umbrella terms and not as external factors themselves. For example, government involvement relates to pushing the low carbon agenda through various means, including policy at various levels, energy sector regulation, building regulations, education and curriculum integration, diversity of energy supply, and energy performance labels. Technological progress is linked to government involvement in many ways, but is also associated with external factors such as technology costs, fuel and electricity prices, energy efficiency and electrification. Other external factors which are not directly linked to these two elements have also been considered, as seen in Figure 14.

It is the view of the project team, based on expertise and the external factors research that the successful rollout of a smart energy and heat system will depend on sufficient technological progress and government support. As such, the team was keen to explore potential future worlds where there are varying degrees of success in achieving optimal states of these two elements, and how these will impact consumer behaviour and potential solutions.

The inclusion of willingness in scenario development was also considered an important feature for WP5.5 and the development of solution scenarios. In adding this third element, the team is better able to understand how willingness changes not only in terms of external factors, but as a result of the solutions being offered. In forming an understanding of external factors and the impact on consumer willingness, the team will be better able to develop suitable future smart system solutions. These elements do not represent entirely separate groups of external factors. Instead, each external factor can be viewed in terms of its influence and dependence on the three above elements. For example, income will depend on Government policy, the influence of income will depend on the money required to adapt smart energy solutions (hence the level of technological process) and income will therefore affect willingness to change. The three elements will themselves be interdependent, each having an effect on the other.

Scenarios were developed based on high and low trajectories of each element, leading to 8 scenarios based on different combinations of high and low futures of each element. These 8 scenarios were then filtered down to four by bringing in one of our assumptions as an eliminating factor – the assumption that our carbon targets are met. Based on this assumption, if at least two of the critical factors have negative trajectories, it is unlikely that carbon targets will be met for that future. These scenarios were then eliminated from further development, leaving four scenarios that we will be discussing further in the next section. Figure 12 outlines these different combinations.

Scenario No.	GOVERNMENT POLICY	TECHNOLOGICAL PROGRESS	CONSUMER WILLINGESS	LIKELY TO MEET CARBON TARGETS?
1	Weak	High	High	Yes
2	Strong	High	Low	Yes
3	Strong	Low	High	Yes
4	Strong	High	High	Yes
5	Strong	Low	Low	No
6	Weak	Low	High	No
7	Weak	High	Low	No
8	Weak	Low	Low	No

Figure 12. Combinations of high and low trajectories of three key elements for future scenario development

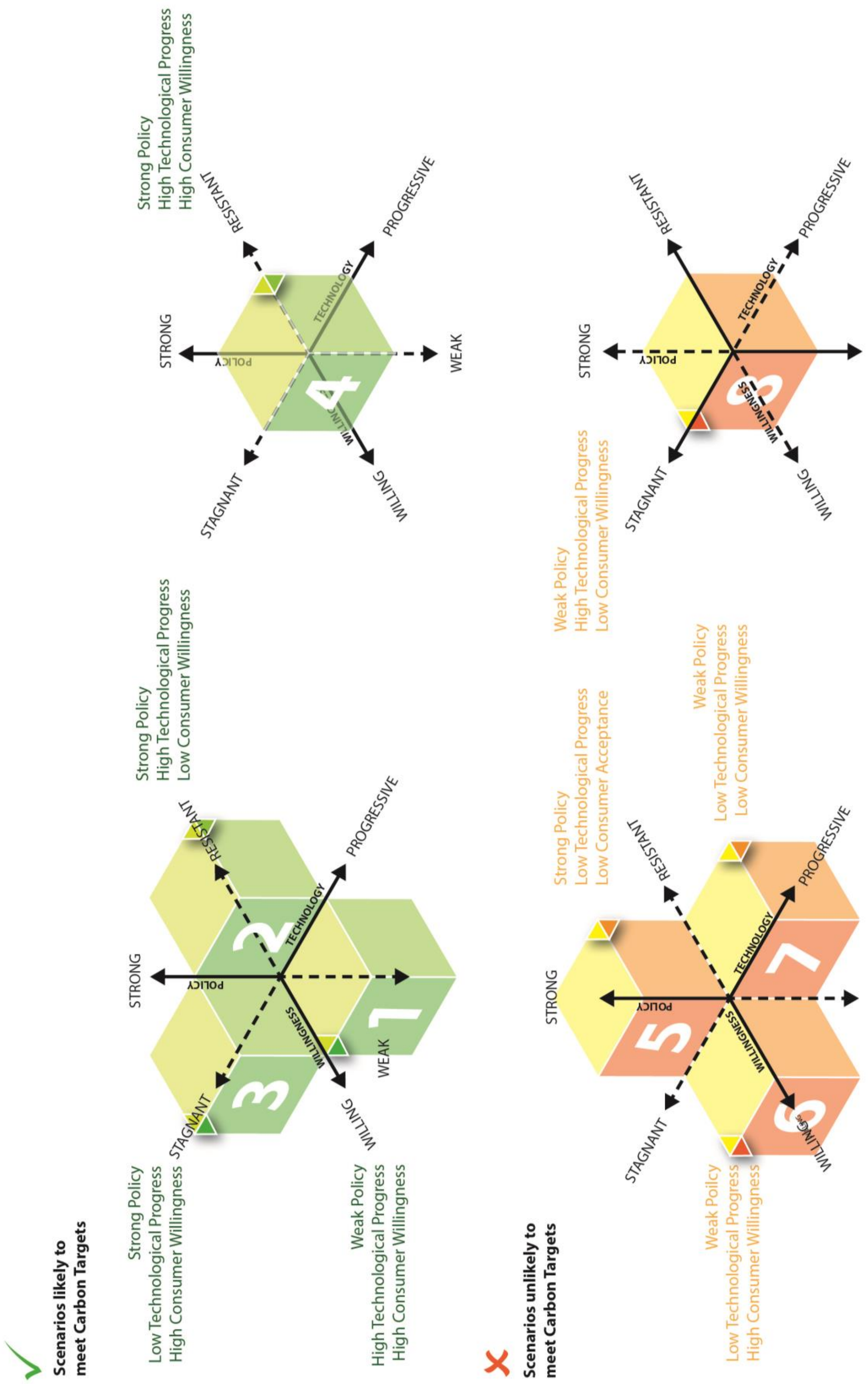

Figure 13: Visual matrix of accepted and rejected scenario combinations

The four scenarios that remain are those which are the more plausible futures where 2050 carbon targets are feasible. The four are the most realistic, both for understanding the future impacts of the external factors, and for developing solution scenarios. The tension between technology, policy and consumer willingness drove the variation between the four scenarios, although all 18 of the previously identified top external factors contributed to the scenario development and were used to characterise the aspect of consumer willingness. Figure 14 summarises how each of the 18 key factors varied for each scenario (where an upwards arrow suggests an increase, a downwards arrow suggests a decrease and a horizontal arrow suggests little change from present day conditions).

Factor	Scenario ONE	Scenario TWO	Scenario THREE	Scenario FOUR
EU policy	↓	↑	↑	↑
National policy	↓	↑	↑	↑
Local policy	↓	↑	↑	↑
Income	↑	→	↑	→
Technology costs	↓	→	↓	↑
Housing tenure	→	→	→	→
Fuel and electricity prices	↑	↑	↑	↑
Aging population	↑	↑	↑	↑
Education	↑	→	↑	↑
Household size	→	→	→	→
Energy efficiency	↑	→	↑	→
Diversity of energy generation	→	↑	↑	→
Electrification	↑	↓	↑	↓
Building Regulations	↑	→	↑	↑
Energy sector regulation	↓	↑	↑	↑
Energy performance labels	↑	↓	↑	↑
External temperatures	↑	→	↑	↑
Extreme weather events	↑	→	↑	↑

Figure 14: Trajectories of external factors under each scenario

The scenarios are intended as an overview that can be used to inform the solution scenarios in WP5.5 and provide a useable framework for the rest of the project. They are also meant to flag potential obstacles and areas of opportunity which should be considered when developing the strategy for the implementation of a smart heat and energy system.

The scenarios are intended to show the range of possible futures (within the constraint of meeting carbon targets). They are, therefore, described as extremes in continuum, with less extreme versions also being possible.

3.2 The role of the ESME model

ESME is a model of the UK's national energy system, covering power, heat, transport and infrastructure out to 2050. It is a tool for exploring how climate targets could be met in the most cost-effective way. It takes assumptions on the current stock of technologies and buildings, along with assumptions on technology characteristics and consumer demand for energy services in the future, and calculates the mix of investment and energy use that would allow consumer demand for energy services to be met in the most cost-effective way, within the constraint of meeting the 2050 climate targets. ESME is focussed on estimating the most cost-effective paths to meeting the 2050 target. It does not attempt to predict what *is likely* to happen out to 2050 – instead it considers which investments and actions *should* occur, if the aim is to meet carbon targets in the least costly way. The challenge for users of the model is then to work out how these investments and actions could best be facilitated, for example through policy intervention, or the removal of commercial barriers.

ESME treats some of the external factors are inputs – for example technology costs and fossil fuel prices. Other external factors are treated as outputs of ESME – such as the level of electrification and the diversity of electricity generation.

Our scenarios have a different focus. We have not focussed on how external factors *should* change, to allow carbon targets to be met at least cost. For many of our external factors (e.g. age, extreme weather events) this would not make sense. Instead, our scenarios aim to describe a set of plausible future states of the world, based on the range of available projections for individual external factors, and on the likely interactions between these external factors. In producing these scenarios, we are not trying to predict the future, we are aiming to produce a tool that can help us explore how future conditions could affect consumer needs and behaviour.

3.3 The Scenarios

3.3.1 Scenario One

PRP stock image

Government Involvement	**LOW**
Technological Progress	**HIGH**
Consumer Acceptance	**HIGH**

The year is 2050. There is considerable progress in low carbon technologies despite weak and inconsistent government policy. The Government has taken a back seat with regard to retrofitting efforts and the market is mainly being driven by the private sector.

Communities have risen to the challenge, and a 'sharing economy' has emerged, along with the rise of community gardens and food shares. This is seemingly an embodiment of the 'Big Society'.

As a result of this high level of consumer demand, technological progress is good, and predominantly market driven. Government, while seemingly lacking conviction on environmental issues, is fully supportive of business and "shiny new technology" as long as it promotes economic growth. This support for supply chain growth means higher production efficiencies, and low-carbon and smart technologies are now more cost-competitive with conventional alternatives than they were 40 years ago. Powered by the spirit of innovation and a "Dragon's Den" culture, a wide range of technologies are now available for use in solution development. The British public are likewise technology savvy as the iPad toddler generation are now the movers and shakers of this future, and they are always keen to adopt new technologies.

The progressive increases in gas and fossil fuel prices, coupled with tangible increased climate change effects throughout the years have led individuals to find solutions to reduce their energy use through various personal means. Awareness of energy and environmental issues is high, but there is a growing discontent with the apathy and inaction of government. Owing to the lack of trust in government and the lack of recognition in authority, Building Regulations are stricter than those in 2013 but enforcement is weak, therefore the only people who comply are those who have to because they won't be able to afford to heat their homes otherwise.

People take shortcuts because they know they won't be caught, reminiscent of the 2013 horsemeat scandal. As such, people are trying to save money and reduce their energy bills in different ways - those who have the means have turned to community initiatives, while others are desperate and are willing to do things illegally. Overall, there is a growing divide in incomes – the growth in high-tech businesses means that a segment of the population is able to cash in on this new business and therefore is able to afford the benefits of smart technologies, but there is also a growing number of people who are struggling to survive in the face of the lack of benefits and subsidies for energy provision.

Consumer behaviour

Growing distrust of the national government has led to very localised programmes, often community-led with minimal local authority involvement.

Consumer energy behaviour for those with lower incomes will be driven by necessity, as they will need to save energy because they can't afford it. Any loopholes found will be exploited, and there may be either resistance to smart systems from some segments as people become increasingly more protective of their personal energy usage because of widespread hacking.

Consumer energy behaviour for those with higher incomes will be driven by the need for social status and for the ownership of the newest technologies.

Overall, energy efficiency improvements have largely occurred on the demand side rather than supply, with a greater uptake of energy-saving technologies by consumers.

Environmental and sustainability issues are given high priority by the public as a result of high population awareness of rise in energy prices and climate change impacts.

Impact on solutions

Solutions will be market-led with advancement with regard to in-home technology, not upstream generation and supply. Technology will have to be attractive to consumers, who will want attractive and easy-to-use products that are worthy of investment. Controls will have to be easy to use, and products should be quickly and easily installed by a local supplier or by the residents themselves. Despite the technological progress in terms of individual technologies, full smart system integration has a hard time gaining ground owing to the lack of political will. As a result, smart technologies that are prevalent in every home are not linked up fully and have not been able to realise their full potential.

There will also be a drive for infrastructure to support demand, including electric vehicle charging points and localised supply chains. Microgeneration will become more popular as consumers focus on personal demand.

EPCs and other product performance labels will be important, as consumers will demand to know the energy use of products, and are likely willing to pay more for energy-efficient appliances and properties.

3.3.2 Scenario Two

PRP stock image

Government Involvement	**HIGH**
Technological Progress	**HIGH**
Consumer Acceptance	**LOW**

The year is 2050. Despite considerable promotion of smart energy systems and low carbon technologies by both government and industry, the lack of market demand means that the cost of smart technologies has remained high throughout the years. Also, the recognition of the impacts of climate change has not been as widespread as predicted, and consumers feel little direct pressure to adapt low carbon technologies and energy-efficient behaviour despite government targets.

Another contributor to the lack of consumer interest is the fact that Britain's predominantly older population do not have the income to spend on expensive solutions in the face of growing problems with pensions, healthcare and housing availability. Despite being reasonably technologically savvy, they are simply not interested. Gas and electricity prices have risen over time, however the lack of affordability of the smarter solutions has meant that consumers have chosen to go for cheaper, more conventional alternatives.

Consumer awareness of environmental issues is at an all-time low, correlated in part to minimal rises in tertiary education levels, and the lack of integration of energy efficiency issues into the national curriculum. Seeing the lack of consumer response, the Government decided back in 2030 to shift its efforts towards decarbonisation via supply-side measures in order to meet its carbon targets without depending on public support.

The progressive shift towards rented properties due to lower incomes has also meant that there is very little interest in property improvement, but there have been promising efforts by the government working with the real estate sector to support green leases in order to provide benefits to both landlords and occupiers.

Technological progress is high but the difficulty in delivering cost-effectiveness means that demonstrator projects have been popping up around the country in the hope of stimulating public interest and enthusiasm, and there have been pockets of interest but not enough to create fully integrated regional-scale smart system solutions.

Consumer behaviour

The continued high cost means few people are willing to take up elements of a smart system and other low carbon technologies unless it is necessitated by building or planning regulations. However, those who are motivated and have the means to install efficient appliances or retrofit their homes are motivated for the need for increased self-sufficiency and energy security. . As a result of frequent past backtracking by government on policy, consumers are wary of government subsidies and incentivisation to reduce the cost of low carbon technologies. Consumers display a lack of trust in new technologies and a paranoia-driven reluctance to take up smart systems in particular, and remained concerned by the risks posed by identity theft and data protection issues.

Impact on solutions

This scenario represents the most challenging world: solutions are available yet expensive and consumers are unenthusiastic about changing their behaviour.

In this scenario, the uptake of solutions is restricted to only those with the income or motivation. Solution scenarios need a very strong consumer motivating element to succeed, i.e. mass awareness programmes, financial instruments, subsidies and incentives.

Solutions that take advantage of technological progress but minimise the impact on consumer lifestyles are likely to have the highest uptake and use. Solution scenarios will require supply-side improvements to complement the progress on the demand side in order to deliver the necessary smart system infrastructure. Strong regulation and policy support, as well as consumer education and awareness will be required to overcome technological constraints and consumer unwillingness to act.

3.3.3 Scenario Three

PRP stock image

Government Involvement	**HIGH**
Technological Progress	**LOW**
Consumer Willingness	**HIGH**

The year is 2050. Despite stable and robust government policy, the potential for innovative technologies remains untapped and today's solutions have remained stagnant since forty years ago. Materials shortages in the raw elements required for the R&D and manufacture of crucial smart system semiconductor elements have meant that progress is slow. Also, rising pollution levels in China finally became intolerable in 2020, leading to a mass shutdown of industrial districts and the end of cheaper overseas manufacturing. These two main factors, in conjunction with increased government environmental sanctions on industrial emissions, have caused the technological sector to stagnate despite high public interest and demand.

As a result, the government has had no choice but to promote conventional technologies that have been in place since 2013. As such, full smart system integration has not been realised but individual or community-based solutions are doing well and contributing to meeting the government's carbon targets.

Consumer willingness has continued to increase as a result of continued government involvement, with the successful integration of energy efficiency information into the national curriculum, and a greater number of people are achieving tertiary levels of education.

The Government is also putting a greater focus on research and development, with increasing funds for advanced low carbon technologies. A lot of promising technologies exist in demonstrator projects and research labs, but the main stumbling block is establishing a reliable supply chain to ensure mass delivery.

Consumer behaviour

In addition to slow technological progress, consumers face a range of constraints such as high energy and technology costs and a move away from home ownership despite high willingness. As a result, government policy supports consumer uptake through subsidies and tax breaks to support uptake of conventional technologies.

However, despite the high cost of smart technology, the continued increase in the cost of fossil fuels and other traditional energy sources has made energy-efficient behaviour more attractive. In this scenario, consumers are also willing to make changes to their lifestyle and to adopt solutions that require some flexibility over their energy use.

Impact on solutions

Technology will be conventional but will require advancements in efficiency.

As a result, the cost of low carbon technology remains high. Climate targets are met through a combination of low-carbon energy sources that are already available now (e.g. wind, nuclear, district heat) and older technologies which, given the lack of technical progress remain costly out to 2050 (heat pumps, electric vehicles, solar PV). Cheaper non-data-linked technologies, such as programmable controls and thermal efficiency improvements, are commonplace and are what people rely on to save energy.

Climate change targets will need to be met by a combination of changes on both the supply and demand side, using existing technology.

3.3.4 Scenario Four

<table>
<tr><td rowspan="3">

PRP stock image</td><td>Government Involvement</td><td>HIGH</td></tr>
<tr><td>Technological Progress</td><td>HIGH</td></tr>
<tr><td>Consumer Willingness</td><td>HIGH</td></tr>
</table>

The year is 2050. Strong policy is matched with high technological progress, making the process of dissemination and uptake relatively easy. In this instance, the UK has come more in line with Scandinavia and other European countries. There is clear dedication to the achievement of emission targets across the UK economy. Since action is being driven from the top, it is easier to meet reduction targets and consumer trust is at an all-time high.

The role of the European Union has remained strong, and stricter Directives have pushed the UK government to implement stronger policies, such as a Renewable Energy Directive, with legally binding requirements. An EU supergrid has been put in place, with continued cooperation between member states.

There is also an increased number of owner-occupiers, as well as greater support and regulation for landlords and private renters in the installation of low carbon technologies in rental properties. For example, rental properties below an EPC rating of C are no longer able to let.

There has been active buy-in from all actors, where the shift to a smart energy system has become normalised.

For the consumers, life has never been better – they live in a world where fridges let them know when they need more milk before they have run out, where energy-efficient appliances are the norm, where grid electricity is clean and green and they get around on electric or hybrid vehicles that are quiet and have very minimal reliance on fossil fuels. Sure, there are still some niggling bits of doubt about data protection and the knowledge that all of their energy behaviour patterns and purchasing decisions are floating around in the cloud somewhere, but the benefits far outweigh the concerns about privacy, and with everyone signed up to it, no-one is really that concerned. Data security systems are well established and there is a high level of trust in the system.

Consumer behaviour

Overall, the process has been made easy, and requires minimal effort by the consumer, as a result of lower costs and information which has been made readily available by the Government. They are largely happy to sit back and allow the government to help them. As such, they are more willing to engage with energy efficiency measures, and to be flexible about the times of day that they demand energy. They will accept greater changes over current types of heat supply. Overall, individuals are largely forced into the acceptance of new technologies through regular phase-out programmes initiated by the government.

It is likely that under this scenario, there has been consistently stable policy over the last 10 years and will continue. Local authorities have brought their energy and environmental programmes in line with national policy.

The cost of low carbon technologies have also come down, while the cost of non energy-efficient technologies, as well as fossil fuels, have risen, making energy efficient behaviour even more common.

Impact on solution scenarios

There is high predictability in this scenario. The combination of a low set of technical constraints and strong policy and government involvement means that this will be the most attractive scenario in which to implement smart energy solutions.

Smart energy system technologies have become the norm and consumers are open to the installation of different technologies and controls.

3.4 Summary

The scenarios explored have provided sufficiently different worlds, useful in creating solution scenarios applicable in a wide range of circumstances.

One of the key differences is whether or not a solution will require policy intervention or if it will be market-driven through high consumer demand. Without strong policy, solutions will need to be made more attractive to convince consumers to invest in them.

The other central concern is whether technological progress will be sufficiently advanced in 2050 in order to replace current low carbon technologies. Future solutions will otherwise need to consider how carbon targets will be met with conventional technologies, and how continued high costs would affect consumer acceptability.

While the scenarios suggest these two worlds are mutually exclusive, a future world is likely to be more fluid, with a mix of policy and market involvement, which will help to promote low carbon technologies and energy-efficient behaviour. As such, the scenarios presented here may be considered more extreme than reality in 2050, but it is worthwhile considering these extremes in order to ensure solution scenarios are sufficiently future-proofed.

It is also clear from the scenarios that there is a place for retrofit in all four future worlds, although the size of that role will depend on the scenario.

Overall, the team concluded that there are three external factors in addition **to technological innovation**, **government policy** and **consumer willingness** that will significantly influence the shape of the world in 2050, and the success of a smart heat and energy system. We have identified these as follows.

- **Income**: Regardless of government involvement, many low carbon technologies will require consumer investment. The scenarios have not considered a fall in income, as existing literature suggests that the average income per person will continue to rise overall to 2050. However, the rate of this change is unclear, as is the relative amount of disposable income per person. The amount of disposable income will highly influence uptake.
- **Fuel Prices**: Energy bills are a consumer's primary interaction with the wider energy industry, and provide a sense of their impact in a tangible way. The degree to which fuel prices increase will put increasing pressure on the consumer, having a direct impact on demand.
- **Climate Change:** As extreme weather events continue to become more prominent and highly publicised, the public's need for energy security is expected to increase. The speed at which the impacts of climate change take place will influence the rate of change in energy behaviour.

4. Outputs and Next Steps

The outputs of this report primarily consist of evidence from the literature to shape and constrain future models and plans (e.g. the model (**WP5.6**) and field trial location criteria (**WP5.9**)), scenarios to conceptualise future worlds in which smart solutions could succeed or fail (e.g. for solution scenarios and characteristics (**WP5.5** and **WP5.8**)) and descriptions of key external factors and their impacts (to inform the primary consumer research (**WP5.4** and **WP5.7**)).

The external factors literature review, however, has also served to identify key areas where there is limited available evidence (i.e. many of the social and economic factors are well covered, whilst other PESTLE factors have limited evidence on their impact on consumer needs and behaviours). This may help inform research areas to focus on in the later part of the project (e.g. the research in **WP5.7**) once consolidated with the findings of the main literature review in **WP5.1**. This identification could also inform the direction of future research beyond this project and beyond the Smart Systems and Heat Programme.

At the current stage of the project, there are two immediate uses of the External Factors work.

- **Workshop and Interview Probes for WP5.4** – Methodology development sessions for the deliberative workshops in WP5.4 (four workshops of 40 people each, including breakouts of 10 participants each) identified that the most useful output of the External Factors work for the qualitative fieldwork would be the description of factors and their impact on consumer needs and behaviours. The scenarios, it was felt, were too abstract or complex to present "cold" to consumers and that asking them to imagine life in these futures would be less useful for this stage of the work than exploring their current situation. As such, a list of probes (**Appendix C**) for each external factor was produced (providing facilitators with example triggers (what might be said by participants in discussions to provide an opportunity to smoothly introduce the factor), example prompts (questions to put to the group) and a rationale for the prompt to allow facilitators to adapt the prompts to fit the discussion. At the time of writing, this list of probes has been used at the first workshop with positive feedback from the research team as to its usefulness in helping provoke useful and relevant discussion within the scope of the groups. This list of probes will also be used in development of the in-home interviews.

- **Draft Locational Criteria Presentation for D5.9(i)** – The first deliverable for WP5.9 seeks to provide the ETI with some initial criteria by which to assess potential areas for the Phase 2 field trial. At this stage of the project, the inputs are based on work completed to date, supported by previous experience of the consortium. As the External Factors work is one of the earliest pieces of work it is, therefore, a crucial input into this deliverable. To date, the systematic approach to identifying key external factors has provided a useful model for crafting the category framework and the evidence from the literature will provide key inputs to criteria that would prevent (or be essential) for a field trial that will be relevant for 2050.

Similar applications from the external factors work will be developed as the other Work Packages begin later in the project (e.g. external factor scenarios shaping the work of the solution scenarios team in WP5.5), and these inputs will be highlighted in the relevant later deliverables.

Appendices and References

Appendix A – Consumer Needs

The following is a report which was developed for **WP5.1 Consumer Segmentation**, titled "A categorisation of residential consumers' energy-related needs for CRaB". The project team has used this report to shape our understanding of needs, behaviour, motivation and rationale.

Introduction

Fundamental needs can generally be related back to comfort, health, safety, productivity, security and happiness. Examples are: achieving thermal comfort (e.g. by heating or cooling), acceptable air quality and lighting that promotes certain moods or enables certain tasks to be carried out; having hot/cooked food and drink; being clean and having clean (dry, mould-free) clothes, homes and cooking/dining items; mobility; and entertainment. Within these fundamental needs, there may be more specific needs, such as how much of the home is heated or to what temperatures.

The definition of "need" is deliberately broad, ranging from objectively "essential for life" to preferences based on individual perceptions. A need exists whether or not a person is aware of either the need itself or the contingent energy use. In some cases, the role of energy may be distant in people's minds from the need itself (e.g. social status may relate to maintaining a temperature higher than necessary for thermal comfort, or using light for aesthetic effect rather than to see things). Needs might relate to a person's own individual needs, social norms and expectations, or standards set by regulators or professional bodies.

Whether the need is personal, social or standard-based, there may be a priority order of needs, although this may be observable only when there is a limit on the resources available to meet the needs (e.g. in cases of fuel poverty). The priority order itself might be:

- observed or reported;
- perceived or objectively defined;
- fixed or flexible;
- dependent on relationships between needs (e.g. an open fire may offer both heat and light, a bath may provide washing, comfort and relaxation);
- related to whether a need is currently met.

Needs may be directly those of the person taking the decision that results in energy use (e.g. I want to read, so I put the light on), decided by negotiation (e.g. I'm OK but my wife wants the light on, so I put the light on) or decided on behalf of someone else (e.g. my toddler needs to see his toys, so I put the light on). Hence, the definition of needs and priorities is socially complex, depending on who is dominant in the decision-making, the needs of a range of persons, and care responsibilities (e.g. foregoing a hot meal so that children can be kept warm).

In this document, "needs" are the needs addressed through energy use (or avoidance of energy use). This is different from the requirements for changing behaviour, which could be expressed, for example, in terms of:

- providing information and services that make it quicker and easier for householders to understand options, take decisions and implement changes;
- facilitating changes on a personal level or a street or neighbourhood level;
- aligning the motivation of different parties (e.g. landlord and tenant);
- clarity over the availability of financial incentives (now and in the future), so that the right time to act is clear and householders do not later regret acting when they did;
- clarity over how the mix of generation of power and heat will develop (e.g. fossil fuel vs renewable vs nuclear, and central vs community generation), since this will influence CO_2 savings and decisions on investment at household level.

Nevertheless, needs can be set in the context the “means, motives and opportunities” framework for behaviour change, where needs are closely aligned with “motives”. The means, motive and opportunity for change need to, in combination, overcome whatever barriers exist – whether they arise from finance, time, habits, routines, established lifestyle choices, personal image or ignorance.

- The *means* is the technology (a characteristic of the building fabric or services) or behaviour that will lead to reduced energy use.
- The *motive* is the reason why households will want to make the change.
- The *opportunity* is the resource (e.g. time, space or money) to make the change.

The means, motives and opportunities, while distinct, are not independent: strong motive (at individual or society level) can lead to the creation, acceptance or discovery of means and opportunity; reliable means can increase (or allow recognition of) motive and make clear the opportunity; and opportunity can allow people to realise motive and create means.

Needs are categorised below under these six main headings.

A. Needs related to the wider implications of energy use.
B. Resource-related needs.
C. Needs related to quality of life.
D. Social needs.
E. Mobility.
F. Regulatory needs.

For category A, the behaviours related to the need would be generically anything that reduces use of energy or CO_2 emissions. For the other categories, some examples are given of the behaviours that relate to the need. Behaviours are expressed in the imperative for consistency but this should not necessarily be taken to imply that a behaviour is recommended.

Any given behaviour may relate to more than one need, so these examples should not be seen as exclusive to the particular need. For example, cooking food fulfils a requirement for health but the way in which it is cooked and served can have a social aspect; wearing clothes is relevant to thermal comfort but the style of dress may be defined more by social needs; a home fulfils a need for shelter but it is much more than that.

A. Needs related to the wider implications of energy use

A1. Save the planet

This refers to a personal desire to reduce risk to the global environment, through:

- *reducing CO_2 emissions to avoid dangerous climate change; and/or*
- *reducing global pollution of the environment (air, land and water) and depletion of natural resources.*

While these are the needs that drive much policy and social action in the energy arena, they are of variable importance to individual people or households. For some people, reducing CO_2 emissions is sufficient motive to shape the way energy is used (or not used). Others either do not believe that climate change is a risk (globally or to them personally), do not think they can make a difference in a global context or see it as somebody else’s responsibility.

Similarly, pollution and depletion of natural resources are major issues for some people but others have a lesser understanding of (and concern for) these issues.

A2. Save the country

This refers to a personal desire to:

- *achieve security of energy supply and national self-sufficiency; and/or*

- *avoid environmental degradation in other countries leading to wars and mass movement of people – some to the UK.*

Again, these needs drive much policy and social action in the energy arena but there is highly variable awareness at the individual and household level. Logically, “saving the planet” does include “saving the country” but there is an additional national element that, for some people, is sufficient motive to shape the way energy is used (or not used).

The crisis in January 2009, when Russia cut off gas supplies to parts of eastern Europe, showed this quite starkly. A country that can be self-sufficient in its energy supply is a more secure country. And environmental degradation in other countries may lead to wars and mass movement of people – both UN Convention refugees and ‘environmental refugees’ – some of them to the UK.[190] The key themes here are conflict and competition: major climate change can severely curtail the resources available to groups of people, who then compete for land or other resources held by others. Realistic scenarios for the 21st century involve people movements measured in hundreds of millions.

A3. Save my neighbourhood

This refers to more local issues, underlying a personal desire to:

- *avoid loss of land, severe weather, floods and property becoming uninsurable and losing value and/or*
- *maintain local security of energy supply.*

There is some tendency to think that it would be nice for the UK to be a bit warmer and only countries that are already hot need to worry. In reality, there is a wide spectrum of risks to individuals in the UK: loss of land, severe weather, floods, and property becoming uninsurable and losing value. Combining this with the issue of energy security, there may increasingly be concern in some quarters over supply to particular premises (as distinct from the country as a whole). Power shortages or wind damage to power lines, for example, may motivate investment in personal or local power generation.

Self-sufficiency is, in this context, a functional aim rather than being related to personal resources (for which, see B3).

B. Resource-related needs

B1. Save (or make) money

This refers to meeting financial needs such as:

- *saving money on fuel bills;*
- *making money by generating energy;*
- *increasing (or maintaining) property value;*
- *getting a bargain or free offer;*
- *spending money on something else, e.g. heating or non-energy needs.*

In this context, money is the motive for behaviour rather than the resource for the behaviour: the payback rather than the investment.

Reducing energy use will generally save money and there is also the opportunity to make money through schemes to reward energy use, such as the Feed-in Tariff. Some energy-efficiency or microgeneration interventions will also enhance the value of the home at point of sale or letting. Conversely, some action or inaction may reduce property value (e.g. through moisture damage or reducing the aesthetic appeal of the home).

Where installation or appliances are offered free or at a substantial (and verifiable) discount, some people may take up the offer simply because of the perceived value. Some people do not easily connect with the motive of *saving* money but are motivated by having money to *spend* on other things, so similar needs may be phrased in different ways.

This need may alternatively be expressed in terms of acquiring energy-efficient buildings or appliances, perhaps based on energy labelling, which may be seen as enhancing the value of buildings that get a good rating.

Examples of links to behaviour[191]

- Use compact fluorescent lamps (CFLs) because of low investment and short payback.
- Use a washing line because it is cheaper than the alternatives.
- Reduce water usage to reduce water bills (if water is metered).
- Don't ventilate to avoid condensation because moisture damage is the landlord's problem.
- Don't maintain heating, cooling and ventilation systems because it is too expensive or poor value.
- Maintain heating, cooling and ventilation systems because a warrantee is invalidated if not serviced as specified.
- Use a dehumidifier to prevent damage to the building from condensation and mould.
- Don't install internal wall insulation because of the risk of failure of vapour barrier or interstitial condensation damage.
- Install internal wall insulation because it's cheaper than external wall insulation.
- Don't install loft insulation because of concerns over financial loss from damage to the building (through blocking ventilation to the roof space, or water pipes/tanks freezing and rupturing).
- Install double glazing because other refurbishment is happening and it's therefore the cheapest time to do it.
- Install a new boiler, heat pump, solar system or double glazing to increase the resale or rental value of the home.
- Don't undertake high capital cost energy efficiency measures because of the cost.

B2. Avoid waste

This refers to a personal desire to reduce wastage of energy or other resources.

Avoiding waste is an element of the needs already described but there is also – for some households at least – an inherent dislike of waste, regardless of whether any money is saved or the prospects for long-term availability of a commodity. This need may be particularly significant for more affluent households where saving money, as such, is less critical.

Waste avoidance may also be a barrier if old, inefficient technology is retained when there would be a net energy or CO_2 benefit from replacing it. For example, when considering replacement of an inefficient boiler, households may feel that it still works and it is therefore a waste to replace it.

Examples of links to behaviour

- Use CFLs because of their long service life.
- Avoid white goods that are perceived as wasteful, e.g. dishwasher (compared with washing by hand), tumble drier (compared with drying on a line).
- Load dishwasher and washing machine it to the maximum recommended level on each use.
- Avoid unnecessary heating by putting on extra clothes or bedclothes.
- Use passive means (windows, shading, thermal mass) to keep cool, rather than air conditioning.
- Eliminate indoor sources of air pollution before increasing ventilation.
- Use windows rather than mechanical ventilation with heat recovery (MVHR) when the temperature is similar indoors and outdoors.
- Set heating controls to avoid heating of empty rooms more than is necessary to avoid damp.

- Reduce water usage in times of drought.
- Install double glazing only if the existing windows are in need of replacement.

B3. Self-sufficiency

This need may be expressed in terms of:

- *fulfilling a desire for self-sufficiency and/or*
- *becoming more in tune with nature.*

This need is likely to relate most strongly to generating energy or using free energy.

Examples of links to behaviour

- Use outdoor lights that are charged during the day by solar power, then switch on automatically at night.
- Dry laundry dried outside to give a sense of connection with nature.
- Install a biomass boiler for personal energy security (i.e. the fuel can be stockpiled to guard against short-term failure of supply).

C. Needs related to quality of life

C1. Wellbeing

This refers to personal needs such as:

- *being comfortable, relaxed, rested and healthy;*

  being free from worries or fears;
- *being productive – in employment or in domestic work;*
- *having safe appliances, building fabric or lifestyle;*
- *having actual or perceived security.*

Some needs are directly met through energy use, e.g.:

- cooking and eating;
- keeping food fit for consumption;
- keeping oneself clean and dry;
- washing clothes or dishes;
- relieving aches and pains (e.g. by applying heat);
- medical treatment (e.g. home dialysis).

Meeting other needs depends on the achieved indoor environment. Certain energy-related behaviours make the indoor environment more or less comfortable and/or healthy – either directly (e.g. insulation making a home warmer, double glazing making the indoor environment quieter and more secure, or heat-recovery ventilation improving indoor air quality and reducing problems with damp, mould and mites) or indirectly (by making more resources available for other needs).

Being healthy and comfortable should also increase productivity although the relationship is not simple or direct. This applies mainly where the home is a workplace (for paid, voluntary or domestic work) but there may also be knock-on effects on work outside the home if consequences for health persist outside the home.

Becoming more comfortable or healthy does not correlate perfectly with reducing energy use, indeed there can be a weak or even negative relationship. A particular example of this is the widespread finding of 'comfort-taking', i.e. that upgrading homes may achieve only a fraction of the anticipated reduction in energy consumption because the occupants take the benefit in higher winter temperatures rather than reduced bills.

There is sometimes good reason for comfort-taking (i.e. it was uncomfortably cold before the upgrade) and sometimes it is a result of inadequate heating controls (or explanation of how to use the controls) or simply a desire to have the luxury of moving around the house in a constant high temperature and light clothing. In extreme cases, energy consumption may actually increase because heating is seen as better value for money when it keeps the home warm, more of the home can be kept warm or more time is spent in the home.

In similar vein, there may be circumstances in which safety may be the consideration that draws someone into behaviour that reduces energy use. This can range from replacing an old boiler (because of fears of fire, explosion or carbon monoxide poisoning) to turning off appliances when they are not in use to reduce the risk of electrical fires or lightning strike. The fear might or might not be well founded and proportionate; from an energy perspective, the issue is whether it influences behaviour.

Examples of links to behaviour

- Choose a location with good daylight for reading, writing, etc. because daylight is perceived as more comfortable or healthier for the eyes than artificial light.
- Leave lights on to create a feeling of security and comfort.
- Use CFLs because they do not need to be changed as frequently as incandescent bulbs and do not become as hot in use, and generally have slightly stronger glass.
- Avoid drying clothes around the house because of the risk of condensation and mould, or reducing the effectiveness of radiators in heating the home.
- Dry clothes indoors because of a perceived risk of theft of items.
- Avoid use of tumble drier because of noise or risk of overheating the kitchen or the appliance itself catching fire.
- Dry laundry in the sun to kill bacteria, mites and fungi.
- Overheat the home because warmer is seen as always better.
- Dress warmly in winter to maintain adequate ventilation without sacrificing thermal comfort.
- Use air conditioning to keep cool because of security fears over opening windows, or noise outside.
- Avoid air conditioning because it is perceived as unhealthy.
- Use windows for ventilation, rather than MVHR, because the MVHR is noisy or smells because the filters have not been cleaned or replaced.
- Use a dehumidifier to prevent harm from mould and mites.
- Install draughtproofing and insulation for thermal comfort and more even temperature within and between rooms.
- Don’t install draughtproofing and insulation because it’s already warm enough.
- Don’t install loft insulation because of health fears about the fibres.
- Install double glazing or external shutters to reduce noise and security risk.
- Over-ventilate because it is perceived as healthier
- Set heating thermostat low because overheating is seen as unhealthy.
- Limit the temperature of radiators to reduce the risk of burns.
- Set hot water thermostat low to avoid scalding.
- Set hot water thermostat high to kill bacteria in stored water.
- Take a long shower or deep bath to relax.
- Maintain heating, cooling and ventilation systems to avoid odours from filters, microbial growth on filters and ducts, carbon monoxide poisoning, noise from fans, breakdown when most needed (hot/cold weather) or stress and worry over the possibility of breakdown.

- Draughtproof the home to keep out wind, noise, odours, dust and dirt, and feel secure and "cosy".
- Don't install internal wall insulation because of concerns about thermal bridging (hence reduced thermal effectiveness and risk of condensation) and summer overheating (because the effective thermal mass of the home is reduced).
- Insulate or draughtproof under the floor to remove the need for a carpet, because of health concerns about carpets (e.g. dust mites).
- Install double glazing to reduce ingress of noise from outside (and possibly also increase freedom to make noise inside), and improve security and safety.
- Install a new boiler because the old one is noisy or is in a location where the noise is intrusive.
- Don't install a biomass boiler because of the smoke.
- Don't install solar thermal water heating because of concerns about scalding or Legionnaires' disease.
- Install solar thermal water heating to reduce noise and pollutant emissions from the boiler.

C2. Aesthetic appeal

This refers to needs related to the look (or feel) of the home or something within it (from the perspective of the householder rather than an aspect of self-image).

Beyond the functional benefits of some energy efficiency measures, aesthetic appeal can be a need in itself: whether the home or some part of it looks (or feels) attractive can have an impact on energy-related behaviour. For example, 'looking modern' is important to many people. Saving space in the home (to avoid clutter) could also be a factor. While some other motives can relate to slow or small benefits, an aesthetic improvement can be immediate and (to the householder) very important.

Examples of links to behaviour

- Use lighting for effect rather than to see by.
- Avoid CFLs because they are seen as having slow warm-up, flicker, poorer light quality/tone, or being bulky and unattractive, or incapable of being dimmed.
- Dry clothes outdoors because it is unsightly to have them round the house or because water dripping on the floor may cause staining or damage.
- Use a tumble drier to get the feel of warm, soft clothes.
- Dry clothes indoors because of a perceived risk of soiling (e.g. from birds, nearby construction work or bonfires).
- Use a dehumidifier to prevent unsightly mould.
- Don't insulate hot water storage, hot water pipes etc. to keep the airing cupboard warm.
- Fit external shutters because they are attractive.
- Insulate radiators (with decorative covers), which reduces heat input to the space and makes control by thermostatic radiator valves (TRVs) less effective because the temperature inside the cover will be higher than in the room.
- Don't install external insulation because it changes the appearance of the home.
- Insulate or draughtproof under the floor to remove the need for a carpet, because of aesthetic preferences.
- Install double glazing to improve the look of the home.
- Install a new boiler to make use of a less obtrusive location.
- Don't install a heat pump because of its appearance.

C3. Make my life easier

This refers to reducing the burden of an activity or task.

If a technology or behaviour can make someone's life easier, or is more convenient, it has an inherent attraction. This is different from the behaviour itself being easy to undertake. So, for example, switching off a light is easy but a 'kill switch' makes it easier to turn off all the lights; turning down a thermostat is easy but simple, effective heating controls make life easier by reducing the need to make constant changes all round the house. This may alternatively be expressed as a need for the right technology to facilitate desired behaviours, saving time or reducing "hassle".

This need may be particularly relevant to changing habits, where offering an alternative, easier habitual behaviour may be effective.

Examples of links to behaviour

- Don't think about changing technology or behaviour because it is too difficult or takes too much time.
- Plug home electronics, such as TVs and DVD players into power strips and then turn these power strips off when not in use.
- Use socket adapters for computers that which switch off peripherals when the computer is shut down.
- Choose appliances with power switches that are obvious and easily accessible (e.g. on the front of the appliance) – and settings (e.g. clocks, timers, preferences) that are saved and restored when the appliance is switched back on.
- Install outdoor lights with a photocell and motion sensor to remove the responsibility of remembering to turn lights on and off.
- Use energy-intensive white goods (e.g. dishwasher, tumble drier) because it is easier than the alternatives.
- Dry laundry in the sun because it is quicker, there are no controls to operate and a washing line is easy to repair and/or replace.
- Dress warmly in winter to avoid having to change dress substantially when going outdoors, especially for short trips (e.g. into the garden).
- Open a window if it gets too warm in the winter because it is easier than turning the heating down (or off).
- Leave heating and hot water on continuously because it is convenient and easier than operating the programmer.
- Use heating controls to avoid constantly having to adjust the heating.
- Don't insulate lofts, hot water storage, hot water pipes etc. to gain storage space.
- Maintain heating, cooling and ventilation systems because (a) a service contract makes it a routine and (b) a breakdown is inconvenient.
- Don't maintain heating, cooling and ventilation systems because it is too difficult or inconvenient or the requirement is not understood.
- Don't install internal wall insulation because it reduces the size of the rooms insulated and requires redecoration (and possibly refitting of interior features, especially in kitchens and bathrooms).
- Don't install internal wall insulation because it makes it more difficult to attach interior fittings to the wall.
- Don't install external insulation because it requires planning permission (e.g. in conservation areas).
- Don't install loft insulation because of the inconvenience of clearing the loft and (depending on the depth of insulation believed to be required), losing storage space.

- Remove loft insulation to create storage space.
- Install double glazing to make maintenance and cleaning easier.
- Install a gas boiler because it responds quickly to changing demands and, unlike a biomass boiler, it takes up little space and has the convenience of mains source fuel rather than needing to order, store and feed fuel to the appliance.
- Install a heat pump for the convenience of a fully automatic system.
- Don't install a heat pump if there is a need to run and maintain a second heating system.
- Don't install solar thermal water heating because it is too complicated to use to best effect.

C4. Confidence in the technology

This refers to people's need to trust the building technology or appliances they are using.

For example, someone may use old technology that they understand and have experience of (or comes with personal recommendation), rather than new

technology (offering greater efficiency and/or facilities) that they are unfamiliar with.

Examples of links to behaviour

- Use windows for ventilation, rather than MVHR.
- Install a gas boiler because it is more familiar than alternatives such as a heat pump or biomass boiler.

C5. Entertainment

This refers to the need for enjoyable pursuits such as watching/listening to TV/radio or recorded material, or playing musical instruments that require electrical power.

C6. Happiness

Happiness combines all the other needs in ways that will vary greatly between people and households but probably include the quality of personal relationships.

D. Social needs

D1. Needs related to self-image or recognition

This refers to a person's identity and aspirations in a social context.

A positive self-image (for individuals or the household as a whole) can result from energy-related behaviours that reduce energy use or CO_2 emissions and, for some people, this can be the most important need. The impact on energy use may be positive (e.g. showing off a new efficient boiler) or negative (e.g. over-heating the home).

This need does not necessarily imply selfishness – it stems from the importance of the social context of actions, and can be altruistic and derive from a feeling of doing something for the wider good (related particularly to the "Save the planet" and "Save the country" needs). It can also relate to national, ethnic or religious identity, with established practices such as approaches to cooking or cleaning being valued. More broadly, it can relate to the individual or derive from taking pride in the neighbourhood, city or country.

The motive can be seen as a mixture of self-esteem and 'kudos', alongside conforming with social norms and aspirations, for example through:

- gaining social acceptance or avoiding social rejection (either generally or within a particular social group);

- teaching skills and responsibility to the next generation (where people interact children in some capacity);
- developing a technical competence or feeling of choice or control;
- association with role models (sports stars, entertainers, intellectual leaders, political leaders).

Examples of links to behaviour

- Switch off lights overnight and when occupants are away from the building.
- Switch off televisions, videos, DVD players, stereos, etc. when not in use (rather than setting to standby mode).
- Use "switching off" to teach their children about responsible behaviour patterns.
- Avoid drying clothes around the house because of sensitivity over visitors seeing it.
- Use a tumble drier because it is old-fashioned to use a washing line.
- Dry laundry dried outside to chat to neighbours or display affluence (e.g. designer labels).
- Dress lightly in winter because dressing warmly is old-fashioned or a sign of poverty.
- Use passive means (e.g. windows, shading, thermal mass) to keep cool/warm to gain a feeling of technical competence and control.
- Use heating and hot water controls to gain a feeling of technical competence and control.
- Draughtproof the home or install insulation in the loft or under a timber floor loft to gain a feeling of technical competence and control.
- Install air conditioning for social status.
- Wash often because of dirty job, sporting activity or illness.
- Wash more often than necessary because of perceived social norms.
- Install double glazing to avoid loss of status.
- Install a biomass boiler, heat pump or solar system for status ("grand designs" image).
- Install a biomass boiler to generate and secure local jobs.

D2. Social interaction

This relates closely to self-image but is more specifically about direct interaction with people inside and outside the home, e.g.

- *living harmoniously within the home;*
- *socialising with friends and family in the home (in person or remotely be telephone etc.);*
- *being involved with, or feeling connected to, local or more dispersed groups;*
- *being supported by other people or groups.*

E. Mobility

This refers to the need to move from place to place, to meet any of the other needs.

In the context of this project, this relates to the charging of electrical vehicles at home and the maintenance of places to keep vehicles.

F. Regulatory needs

This refers to a need to comply with mandatory requirements – either legal (such as those in the Building Regulations) or industry-based (e.g. those imposed by professional bodies or lender/landlord organisations).

Examples of links to behaviour

- Install an efficient boiler because this is the only replacement available.
- Accept a smart meter because this is a requirement (in future).

Appendix B – Linking needs and external factors

In this appendix, we set out the analysis that underlies the assessment of the likely impact on needs of external factors.

This analysis draws on both empirical evidence and theory. Where a need is omitted in an external factor table, it means we have not found a relationship between that need and the factor.

Political factors

This section looks at EU policy, national environmental policy and local policy. In these tables, we focus on the direct impacts of policy.

Table 1: EU policy and consumer needs

EU Policy	Expected theoretical relationship	Empirical evidence	Conclusions
Save the planet	EU leadership could spur international momentum towards a sustainable low carbon economy. To the extent that people are happier to act to save the planet when they believe wider action is occurring, and they are adding to a greater whole, this may increase consumer needs in this area. Alternatively, some people bear a resentment of EU action and may react against it.		EU policy on climate change could increase consumers' need to save the planet.
Self-sufficiency	The impact on EU policy on self-sufficiency will depend on the strength of the political relationship between the UK and the EU. This could lead to individuals feeling EU intervention encroaches on their ability to be self-sufficient politically, and therefore it may increase their need to be self-sufficient on a micro scale.		Strong EU policy may increase consumers' needs for self-sufficiency.
Confidence in technology	Policy endorsement should increase confidence.		Strong EU policy may increase consumers' confidence in technology.

Table 2: National policy and needs

National Policy	Expected theoretical relationship	Empirical evidence	Conclusions
Save the planet Save my country Save my neighbourhood	National policy could increase needs in this area by making it clear that others in the country are also taking action.	In terms of new measures to help reduce consumption, 46% of those interviewed in the UK thought the Government should provide more information on how to use energy efficiently.[192] In a European study, 37% of UK respondents felt the Government should adopt higher efficiency standards for energy-consuming equipment.[193]	National policy could increase consumers' wider needs.
Make my life easier	In addition to providing financial incentives, Government schemes may make it easier for consumers to make decisions and access suppliers.		Strong UK National may make consumer's lives easier.
Confidence in technology	Policy endorsement should increase confidence.		Strong UK National may increase consumers' confidence in technology.
Regulatory needs	An increase in policy interventions will increase consumers' regulatory needs.		Increased national policy will increase regulatory needs.

Table 3: Local policy and needs

Local Policy	Expected theoretical relationship	Empirical evidence	Conclusions
Save the planet Save my country Save my neighbourhood	The concept of "Building a Big Society" has led to policies that aim to give more responsibility to individuals, communities and local councils to solve climate change problems. To the extent that this empowers people, it may lead to greater needs in this area. People may also feel more motivated by policies that involve their communities.	A programme in Woking helped to encourage public/private partnerships through its holistic approach, helping to blend the interests of local commercial enterprise and the larger social and environmental interests of the council.[194]	Local policy will likely have a positive impact on consumer needs in this area.
Social interaction/self-image	Strong local policy may increase consumers' needs for social interaction by promoting community values.		Local policy may have positive impacts on consumers' needs for social interaction.

Economic factors

This section deals with the economic factors: income, technology costs, energy prices and housing tenure (by housing tenure, we mean whether the property is rented or owned by the occupier).

In most cases, we can assume that the needs and preferences examined in this table are normal goods (in economic terms) and therefore that demand for them will increase as disposable income increases. We also assume that changes in costs will have an income effect – that is, if costs of one good fall, consumers will have increased disposable income.

For technology costs, we look at the impact of both relative and absolute smart/low-carbon technology prices on needs, as well as the cost structures associated with these technologies (i.e. the initial capital costs relative to running costs). These factors are looked at jointly, as the empirical literature tends not to distinguish between relative and absolute cost impacts. The text indicates where theoretical relationships are expected to result from relative costs, absolute costs, or features.

Table 4: The relationship between income and needs

Income	Expected theoretical relationship	Empirical evidence	Conclusions
Save the planet	If it is possible to assume that wider needs to save the planet, country or neighbourhood are normal goods, then the priority given to this need would be expected to rise with incomes.	A population segmentation analysis of environmental behaviours by Defra found that those with the most pro-environmental attitudes[195] were most likely to have household income of £40k and over per annum.[196] A survey by the DETR in 2001 found that protecting the environment was often given as a reason for reducing electricity, gas or car use by those in the highest two social classes.[197]	Rising income may have a positive impact on the weight given to these wider needs in decision making.
Save my country			
Save my neighbourhood			

Income	Expected theoretical relationship	Empirical evidence	Conclusions
Save or make money	Increasing absolute incomes may mean that households face less difficult trade-offs when choosing their energy behaviour, reducing the priority given to the need to make or save money relative to alternative drivers of behaviour: This is because the marginal benefit of an additional pound of savings falls as income rises.	Adoption of energy efficient technologies rises with income; however, this could be driven by other factors, such as the fact that higher income people are less capital constrained. The DETR 2001 survey found that those in the highest social class (associated with higher incomes) were less likely to have cut down on their electricity, gas or water use.[198] Respondents in the lowest social classes were more likely to give saving money as a reason for cutting down on car use.[199]	The required expectation of saving or making money is likely to rise with income. In this model, the motive would apply to higher potential savings or gains as income rises. For example, at loer income levels, people would turn out the lights to save money (in small amounts), whereas at higher income levels, people would invest in PV and other similar technologies to save and make moneys (in large amounts).
Avoid waste	Avoiding waste could be seen as a preference, and if this preference is a normal good, then demand for it would be expected to rise with income. Alternatively, waste may be seen as a convenience or luxury to those on higher incomes.	Adoption of energy efficient technologies rises with income; however, this could be driven by other factors, such as the fact that higher income people are less capital constrained.	Rising income may have a negative or positive impact on the need to avoid waste.
Self-sufficiency	Increasing income may increase the drive to be self-sufficient if this preference is viewed as a normal good. Alternatively, some people with a desire for self-sufficiency may accept a lower income and standard of living (as general perceived).		Rising income may have a positive impact on the drive for self-sufficiency.
Wellbeing	Individuals with higher incomes may have inherently healthier homes, so that the need to enhance well-being does not materialise in practice.		Rising income may have a positive impact on the drive for wellbeing

<table>
<tr><th>Income</th><th>Expected theoretical relationship</th><th>Empirical evidence</th><th>Conclusions</th></tr>
<tr><td>Aesthetic appeal</td><td rowspan="2">Household behaviour could become more driven by aesthetic appeal and the need to reduce the burden of activities and tasks as incomes rise.

For example, this could be the case if the range of technologies available to meet these needs is wider for those on higher incomes, or if the preferences for aesthetic appeal and “making life easier” are normal goods. In contrast, lower income households may be more constrained in the technologies available to reduce the burden of activities or tasks and improve aesthetic appeal, and this could act as a barrier to these needs driving behaviour.</td><td rowspan="2"></td><td rowspan="2">Rising income may have a positive impact on the weight given to aesthetic appeal and making life easier in decision making.</td></tr>
<tr><td>Make my life easier</td></tr>
<tr><td>Confidence in the technology</td><td>Because of their lower appliance turnover rates, those on lower incomes may place more weight on the need to have confidence in technology as they would be likely to keep the technology for longer. This may mean that higher incomes over time reduce the priority given to the need for confidence in technology. However, this may not apply to low-carbon technologies such as heat pumps, where replacement rates are likely to be low regardless of income.</td><td></td><td>Higher incomes may reduce the priority given to the need for confidence in technology.</td></tr>
</table>

Income	Expected theoretical relationship	Empirical evidence	Conclusions
Entertainment	Increasing income may increase the desire for entertainment and happiness if this preference is viewed as a normal good, or at least the ability to meet the need.		Rising income may have a positive impact on the need for entertainment and happiness
Happiness			
Self-image	Increasing income may to increase the needs relating to self-image, social interaction and mobility if these are viewed as a normal goods.		Rising income may have a positive impact on the needs for self-image social interaction and mobility.
Social interaction			
Mobility			

Table 5: The relationship between technology prices and cost structure and needs

Technology prices and cost structures	Expected theoretical relationship	Empirical evidence	Conclusions
Save or make money	High absolute prices of smart technologies or long-term cost structures associated with smart and low-carbon technologies could increase the motivation to save or make money because of income effects. For example, a consumer's energy behaviour may become more driven by financial concerns if they are trying to recover high capital costs from a technology.	There is evidence that the cost of smart energy services relative to the conventional alternatives is likely to impact on their uptake. For example, focus group participants in the BarEnergy project[200] stated that higher costs associated with energy-efficient appliances were one of the main barriers to adoption. Similarly, survey evidence on adoption of energy-efficiency measures renewable technologies found barriers to adoption included capital costs and perceived costs outweighing energy savings.[201] Another survey found that technologies being unlikely to last long enough to pay back the initial cost was amongst the reasons households chose not to adopt energy-efficiency measures and renewable technologies.[202]	High costs (relative or absolute) and front-loaded cost structures associated with smart technologies may increase the drive to save (or in the case of some LCTs to make) money. The overall impact of this factor may increase over time as adoption of low-carbon technologies is projected to rise.
Avoid waste	Similarly, high relative prices of smart or low-carbon technologies and the cost structures associated with low-carbon/micro-generation technologies may also reduce the motivation to avoid waste. One aspect of avoiding waste is to keep old, but still functioning, items because it seems wasteful to dispose of them.		High relative prices of smart/ low-carbon technologies may reduce the priority households place on avoiding waste.

Technology prices and cost structures	Expected theoretical relationship	Empirical evidence	Conclusions
Self-sufficiency	High relative or absolute prices of smart or low-carbon technologies may reduce the need to be self-sufficient through the income effect. That is consumers may feel less well off, and less able to pursue preferences such as self-sufficiency		High relative or absolute prices of smart/ low-carbon technologies may reduce the need to be self-sufficient.
Wellbeing	Again, the pursuit of wellbeing may be reduced through the income effect.		High relative or absolute prices of smart/ low-carbon technologies may reduce the pursuit of wellbeing.
Make my life easier	Higher initial investment costs or long payback times may increase the importance given to the need for aesthetic appeal or making life easier. For example, if a smart appliance is likely to have a relatively long payback period, consumers may attach more value to its non-financial benefits such as reducing the time required to spend on tasks (e.g. through automation functions). High relative smart technology prices (or cost structures involving a high upfront capital cost) may also make consumers less able to adopt appliances that would enable them to make their life easier in the first place, e.g. by meaning that consumers are unable to afford appliances which facilitate DSR.		High investment costs or long payback times associated with smart/ low-carbon technologies may increase the importance placed on aesthetic appeal and making life easier.

Technology prices and cost structures	Expected theoretical relationship	Empirical evidence	Conclusions
Confidence in the technology	Similarly, high initial investment costs and long payback times associated with smart and low-carbon technologies may raise the importance attached to the need to have confidence in the technology. For example, when making a long-term decision or taking a risk (that the long-term operational cost savings will outweigh the initial capital investment), households may pay more attention to personal recommendations and their experience of the technology than when purchasing a technology that represents a relatively smaller investment (or has a shorter payback time).		High initial investments and long payback times associated with smart of low-carbon technologies may raise the need for confidence in technology.
Entertainment	Again, the pursuit of entertainment, happiness, social and mobility needs may be reduced through the income effect.		High technologies may reduce the pursuit of these needs.
Happiness			
Social needs			
Self-image			
Social interaction			
Mobility			

Table 6: The relationship between energy prices and needs.

Energy Prices	Expected theoretical relationship	Empirical evidence	Conclusions
Save the planet	If these wider preferences are viewed as normal goods, then higher energy prices could reduce these preferences through the income effect.		Higher energy prices could reduce the preference to save the planet, country, or neighbourhood as a driver of energy behaviour. Alternatively, higher prices could support actions based on these needs, where one person needs to persuade another in the household.
Save my country			
Save my neighbourhood			

Energy Prices	Expected theoretical relationship	Empirical evidence	Conclusions
Save or make money	Higher energy prices may result in households being more likely to take up DSR measures or adopt energy efficient technologies (to save money) or renewable technologies (to earn money and substitute away from fossil fuels).	Higher prices generally lead to lower energy consumption. A UK study found a long-run price elasticity of demand of -0.23, using data from 1972 to 1994 and controlling for other factors affecting demand such as income.[203] The US Department of Energy uses a long-run (20 year) elasticity of -0.31 for domestic demand and -0.25 for commercial demand.[204] US evidence from 2001-2008 suggested that elasticity had fallen since deregulation, to a range of -0.12 to -0.17.[205] One review found households may become more responsive to energy saving measures as energy prices increase.[206] Higher prices resulted in faster adoption of energy-efficient technologies and were correlated with increased spending on measures to save energy. This suggests that households are driven by the need to save money.	There is reasonable empirical evidence suggesting that consumers become more driven by the need to make or save money as energy prices rise.
Self-sufficiency	If the need to be self-sufficient is a normal good, higher energy prices could lower the priority given to this need, via the income effect. Alternatively, higher energy prices could increase the motivation to become self-sufficient.		Higher energy prices may have a positive or negative impact on the need to be self-sufficient.

Energy Prices	Expected theoretical relationship	Empirical evidence	Conclusions
Wellbeing	Rising energy prices could reduce the weight given to these needs through income effects (assuming that both aesthetic appeal and making life easier are normal goods so demand rises as incomes rise).		Higher energy prices may reduce the priority attached to these needs.
Aesthetic appeal			
Make my life easier			
Confidence in the technology			
Entertainment			
Happiness			
Social needs			
Self-image			
Social interaction			

Table 7: The relationship between housing tenure and needs.

Housing Tenure	Expected theoretical relationship	Empirical evidence	Conclusions
Save or make money	Increased renting may reduce the priority given to making long-term savings by adopting energy-efficient technologies. This is for two reasons. First, tenants are unlikely to invest in items they will not be able to keep. Second, landlords may pay for appliances while the tenant pays the electricity bills,[207] which could act as a disincentive to purchasing more energy efficient appliances as the benefits (e.g. reduced bills) accrue to the tenant while the landlord bears the upfront cost.	This is supported by the evidence. A literature review found that renting lowers uptake of energy-saving technologies, particularly for technologies involving a large upfront cost, such as thermal insulation.[208]	An increased proportion of households renting could reduce the drive to save money in the long-term when purchasing appliances, owing to split incentives.
Aesthetic appeal	An increase in renting relative to owner-occupation may reduce the weight households are able to give to quality of life considerations such as aesthetic appeal, confidence in technology, and making life easier in their energy behaviour. This is because tenants may have less control over the choice of appliances in their home (e.g. where they are supplied by a landlord), or they may live in the property for a shorter time than a homeowner, making tenants unable to realise longer-term benefits. However, landlords may have greater need to be confident in the technology, from the perspective of avoiding breakdowns, especially if they are personally responsible for repairs.		Increased renting may have a negative impact on the consideration given to aesthetic appeal, making life easier, and confidence in technology.
Make my life easier			
Confidence in the technology			

Social factors

In this section, we look at social factors: the ageing population, education and household size.

Table 8: The relationship between the ageing population and needs.

Aging Population	Expected theoretical relationship	Empirical evidence	Conclusions
Save the planet Save my country Save my neighbourhood	Age could have influences in two directions. From a personal perspective, older people could have less interest in the future, yet they can have a stronger sense of legacy and a concern for future generations, including their own children and grandchildren. They may also have greater experience of dramatic change, and understand its implications.	The research council study of the UK population indicates that individuals over 51 were more likely to show concern for environmental change than other age groups.[209] The committed environmentalists in a UK-based cluster analysis of conservation related behaviours were more likely to be older.[210]	Changing age structures are likely to increase the need to protect the local and global environment.
Save or make money	Age effects may be mediated by factors such as income, tenure and the difference between payback period and life expectancy.	Elderly people in the UK are more likely to be in fuel poverty. It is therefore possible that they have a greater need to save money. [211] The empirical evidence is mixed concerning saving rates and age. The IFS and the bank of England find that the elderly on average have higher savings rates.[212 213] But Hussain (1998) who controls for depletions in pension funds, projects that personal saving rates will decline from 12% in 2005 to 9% in 2040 as a result of an ageing population demographic change. Miles (1999) projects a fall in the UK national savings rate to 8% as a consequence of ageing. [214 215]	Based on the evidence, it is difficult to conclude how an ageing population will affect the need to save or make money.

Aging Population	Expected theoretical relationship	Empirical evidence	Conclusions
Avoid waste	Dislike of waste may increase with age although this could be related to the current generation of people aged 60+ having experienced post-war shortages.	In a Defra study of pro-environmental behaviours in the UK, the segment who was most motivated to act by the need to reduce waste were nearly twice as likely to be over 65.[216]	An ageing population is likely to have a positive impact on the desire to avoid waste.
Wellbeing	Older people have at the same time, a greater need to avoid extremes of hot and cold and less awareness of that need and ability to meet it.	Defra analysis finds that older people and children are more vulnerable to heat waves. The likelihood of heat waves in the UK is projected to increase.[217] Older people are also move vulnerable to cold.	An ageing population is likely to be associated with greater numbers of people potentially vulnerable to high and low temperatures, and therefore with a need to protect their wellbeing through their heating system.
Make my life easier	Changing age structures may increase the need for convenience. Owing to health factors, the burden of everyday activities can increase into old age. Therefore, with a higher proportion of elderly people, the need for convenience within homes is likely to increase. On the other hand, older people may spend more time at home and therefore may have more flexibility in how they use their energy – for example, they could use appliances at off-peak times.	EDRP showed no age effect on propensity to shift consumption in response to a time-of-use tariff.	An aging population may increase the need to make life easier in some ways, and decrease it in other ways.
Entertainment	Changing age structures could increase the need for entertainment: with a projected rise in the number of people above working age, the leisure time of these individuals would be expected to increase. It is plausible to expect that a proportion of this leisure time will be allocated towards entertainment.		An ageing population could have a positive impact on the need for entertainment at home.

Aging Population	Expected theoretical relationship	Empirical evidence	Conclusions
Mobility	An ageing population could reduce the need for mobility: with a greater proportion of the population above working age, there may be less need to travel to and from work.		A change in age structures will have a negative impact on the need for mobility.

Table 9: Education and needs

Education	Expected theoretical relationship	Empirical evidence	Conclusions
Save the planet Save my country Save my neighbourhood	Higher education levels are likely to be associated with a greater awareness of global, national and local issues. A greater awareness of these issues may lead to greater needs in this area.	In a survey of British social attitudes, having degree level education was the most important factor in determining the level of individual environmental activity.[218] In a separate study, Defra found that the segmented population group that held the most pro-environmental beliefs were also the most likely to have a degree. The two segments that showed the lowest level of environmental concern were more represented by those with low levels of qualifications.[219]	A rise in the number of UK graduates is likely to increase the need to protect the local and global environment.

Education	Expected theoretical relationship	Empirical evidence	Conclusions
Save or make money	There may be a positive relationship between education levels and the need to save money. Higher education levels may be associated with better decision-making including greater integration of future conditions into decisions. The objective need may be less, since graduates tend to earn more and have better long-term prospects. But more educated people may give greater importance to saving money and be better equipped to do it.	There is evidence that adoption of energy efficient technologies rises with levels of education. [220] [221] Education is also positively correlated with saving rates. An IFS study finds those with the least education (those who left full-time education at or before the age of 16) saved less than those who stayed in school past the age of 16,[222] although it is unclear whether this is the result of a lesser interest in saving or because they had less capacity. A study of the impact of workplace initiatives to reduce carbon usage found that for lower skilled workers, incentives and sanctions could be important levers in addition to simply awareness-raising activities. With financial incentives being great in this context, those with lower skills may have a greater need to make or save money overall. [223] A European Commission study on attitudes towards energy found a positive association between education and responsiveness to energy efficient actions. For the majority of the questions, the longer the duration of the respondent's education, the more likely they are to respond positively to actions and costs which improved energy efficiency and security[224].	A rise in education levels is likely to have a positive impact upon the need to save money.

Education	Expected theoretical relationship	Empirical evidence	Conclusions
Make my life easier	Higher education levels may confer an ability to handle more complex choices and actions, but not necessarily the desire to do so.	There is some evidence that higher education levels may be associated with a decreased need for simple and easy to use technologies. A lack of basic literacy and numeracy skills has been associated with reducing effective communication with smart systems, low trust in others and having a lower opinion of personal capacity to change anything.[225]	An increase in the number of UK graduates may reduce the need for technologies to be easier to use.

Table 10: Household size and needs

Household Size	Expected theoretical relationship	Empirical evidence	Conclusions
Save the planet Save my country Save my neighbourhood	People in small households may find it easier to live according to their own ideals, but larger households of like-minded people will receive more support.	A UK-based cluster analysis of environmental behaviours finds that committed environmentalists were more likely to live in smaller households.[226]	The projected decline in household size may be associated with increased environmental concern.
Avoid waste	In smaller households, individuals may feel more responsible for any waste.	An ESRC UK study found that there is a statistically significant negative relationship between household size and recycling rates.[227] This could in part be driven by a difference in relative needs to avoid waste amongst household sizes.	The projected decline in household size could have a positive impact on consumer needs to avoid waste.
Make my life easier	Single person households are likely required to provide a greater effort per person to maintain cleanliness and household comfort than households with two adults. Therefore, single person households may have a greater need to make their lives easier to help deal with this additional burden. Alternatively, the social context of making decisions is simpler in smaller households. This may make positive environmental decisions more likely.		A rise in the number of single person households could increase UK consumer needs to make their lives easier.
Social interaction	People living in single person households will look for external channels for social interaction. This could increase the need for social interaction amongst these households.		A rise in the number of single person households is likely to increase the need for social interaction.

Technical factors

This section looks at the impact of electrification, the diversity of energy generation and efficiency improvements. By electrification, we mean the move towards decarbonisation and the electrification of heat and transport, which is widely believed to be required for 2050 carbon targets to be met.

Electrification

Table 11: Electrification and needs

Electrification	Expected theoretical relationship	Empirical evidence	Conclusions
Save the planet	If increased electrification of domestic energy use, including heat, is accompanied by a widespread decarbonisation of the UK energy grid, many of these wider needs may be met. Therefore consumers may have fewer remaining needs in this area. Alternatively, needs related to country and neighbourhood may increase related to concern of nuclear plants and the loss of land and amenity to renewables.		If electrification occurs with increased renewable sources and reduced fossil fuel use, many consumer needs to save the planet may have been met. They may therefore have fewer remaining needs in this area.
Save my country			
Save my neighbourhood			
Save or make money	Electrification is likely to lead to higher upfront costs and lower marginal costs for many energy services. This may reduce the impact of consumers' need to save money.		An increasing electrification of energy generation and products may reduce the impact of consumers need to save money.
Make my life easier	Electrification could simplify control of heating and permit more precise control in space and time.		
Aesthetic Appeal	Electric heating may have greater potential for aesthetic appeal because no combustion appliance is required.		

Diversity of energy generation

Table 12: Diversity of energy generation and needs

Diversity of energy generation	Expected theoretical relationship	Empirical evidence	Conclusions
Save my country	A diverse energy supply is likely to increase the ability to meet this need through improved national energy security.		
Save my neighbourhood	A diverse energy supply is likely to increase the ability to meet this need through distributed generation.		
Self-sufficiency	To the extent that it increases security of supply of energy, a more diverse energy generation may increase consumers' willingness to rely on energy provided from central sources.		A diverse energy generation may lead to a reduction in consumers' needs to be self-sufficient.

Energy Efficiency[228]

Table 13: Energy Efficiency Improvements and needs

Efficiency Improvements	Expected theoretical relationship	Empirical evidence	Conclusions
Save or make money	There is real opportunity for individuals to save money and reduce their waste, as a result of efficiency improvements through reduced energy bills and overall reduction in energy usage.		
Avoid waste			
Wellbeing	Savings and reduced waste may be countered by consumer 'take-back' or the rebound effect (where reduced costs mean individuals use more energy for improved comfort).		Efficiency improvements may have positive impact on individual well-being.

Legal factors

In this section we look at legal factors and needs, considering regulation of the energy sector, Building Regulations and product performance labels.

Regulation of the Energy Sector

Table 14: Regulation of the energy sector and needs

Regulation of Energy Sector	Expected theoretical relationship	Empirical evidence	Conclusions
Save or make money	The relationship between energy sector regulation and the need to save or make money is likely to increase, as energy providers continue to promote energy saving behaviour (either through efficiency programs or feed-in tariffs). As a result, consumers will likely be able to both save and make money. However, increases in unit prices may result in the perception of the opposite: that regulation is increasing their costs.		Regulation of the energy sector is likely to have a positive impact on an individual's ability to save or make money.
Wellbeing	The Energy Companies Obligation will create a legal obligation on certain energy suppliers to improve the energy efficiency of domestic households, targeting the most vulnerable. More generally, regulation tends to take into account both energy efficiency and reduction in fuel poverty.		Regulation of the energy sector may reduce consumers' remaining needs in this area.
Make my life easier	Continuing regulation of the energy sector will include increased transparency and information for individuals in order to better understand their energy use. Ofgem has proposed a radical shake-up of the retail energy sector. This aims to enable consumers to better understand what is on offer and more easily choose the right supplier and best deal for them.		Reduced complexity in the retail sector may mean that consumers have fewer needs to make their life easier in relation to supplier and tariff choices.

Energy Performance Labels

Table 15: Product performance labels and needs

Energy Performance Labels	Expected theoretical relationship	Empirical evidence	Conclusions
Save the planet	By increasing consumer empowerment, product performance labels may increase or respond to consumers' needs to save the planet, save or make money and avoid waste.		Product performance labels may be positively associated with consumer needs in these areas.
Save or make money			
Avoid waste			
Confidence in technology	Energy performance labels make consumer's lives easier in relation to product selection and confidence in technology		
Make my life easier			
Regulatory needs	Performance labels can be a forerunner of regulatory needs, and help to avoid the need for regulation.		

Building Regulations

Table 16: Building Regulations and needs

Building Regulations	Expected theoretical relationship	Empirical evidence	Conclusions
Save or make money	While stricter Building Regulations may require greater capital costs for consumers and businesses, the long-term affect will be significant energy savings. Consumers' requirements for further savings may therefore be reduced. Building requirements for renewable energy may also allow consumers to make money from the energy they generate from microgeneration.	More energy-efficient buildings will typically save consumers over £150 per year on energy bills compared with homes being built in May 2010.[229]	Building regulations may reduce consumers' needs to save or make money.
Avoid waste	As energy efficiency is promoted in Building Regulations, energy demand will be reduced and less energy will be wasted overall. Consumers' requirements for further waste avoidance may therefore be reduced.		Stricter Building Regulations may reduce consumers' remaining needs in this area.
Wellbeing	While stricter Building Regulations may help to reduce the number of fuel poor homes and improve internal comfort in winter, there are concerns regarding overheating in summer if there is not sufficient provision for passive cooling.		Stricter Building Regulations may have positive or negative impacts on consumers' wellbeing.
Aesthetic appeal	As stricter Building Regulations require improved performance for new homes, there would be aesthetic concerns if the Regulations should at any time extend to existing homes with regard to the insulation of facades, or changing 'character' windows.		Changes in Building Regulations may conflict with consumers' needs in this area.

Building Regulations	Expected theoretical relationship	Empirical evidence	Conclusions
Confidence in the technology	Building Regulations that involve new technology will require that adequate information is disseminated among home owners and residents. It will also require appropriate accreditation of installers in order for residents to feel confident in the work being done and the technology being installed. Consumers' remaining needs in this area may therefore be reduced.		Building regulations may reduce consumers' remaining needs in this area.

Environmental factors

This section covers the impact of environmental factors. Here we deal with the likely impact of climate change. We consider the impact of external temperatures and extreme weather together.

External Temperature and Extreme Weather

Table 17: External temperature, extreme weather and consumer needs

External Temperature and Extreme Weather	Expected theoretical relationship	Empirical evidence	Conclusions
Save the planet	With a 3°C temperature increase, there could be increased impacts upon national infrastructure resulting from flooding, storms, heat waves and sea level rise. A rise in extreme weather could increase consumer awareness of the negative impacts of climate change and therefore may increase needs in this area.		As consumers feel the impacts of climate change, their needs to save the planet, country and neighbourhood may increase.
Save my country			
Save my neighbourhood			
Save or make money	Increased temperatures may decrease consumers' expenditure on heating but may increase their expenditure on cooling. It is therefore not clear what the impact on resource related needs might be. The damage to property as a result of extreme weather and flooding could increase the need to save money, other than by reducing energy use.		Increased external temperature and extreme weather could have a negative impact on an consumers' needs to save money and avoid waste,
Avoid waste			

External Temperature and Extreme Weather	Expected theoretical relationship	Empirical evidence	Conclusions
Self-sufficiency	Rising sea levels or extreme weather events could substantially impact upon the resilience of local infrastructure such as power supply[3] and the adequate protection of vital energy supplies which could potentially impact thousands of consumers are left without power in their homes due to extreme weather events. If an increase in extreme weather events leads to more interruptions of energy services, they may increase people's drive to be self-sufficient.		Increased external temperature and extreme weather could increase consumers' need to be self-sufficient.
Wellbeing	As temperatures and extreme weather events rise, overall wellbeing may decrease. The need to increase wellbeing through energy services may therefore increase.	In August 2003, a heat wave caused 2,000 premature deaths in the UK alone and predictions suggest that heat-related deaths may increase in the UK by 540% by 2080, with older people the major victims.[230] Cold winters can lead to greater numbers of premature deaths at present, so rising external temperatures could reduce overall mortality rates.	Increased temperature and extreme weather may increase consumers' need for wellbeing.
Make my life easier	The increase in extreme weather events over the next 50 years increases the likelihood of more consumers being left without power in the event of flooding and struggling to keep their homes cool in summer months. Similarly related to overall wellbeing, life may be made more difficult with increasing temperature and extreme weather events.		Increased temperature and extreme weather events may increase consumers' needs to make their life easier.

External Temperature and Extreme Weather	Expected theoretical relationship	Empirical evidence	Conclusions
Self-image	If changes in weather lead to wider acceptance of anthropogenic climate change, energy inefficiency could become less socially acceptable and self-image could become more closely linked with combating climate change.		

Appendix C – External Factors Probes

The following list of probes for focus groups is based on the work of WP5.3 External Factors. In this work, 18 key external factors were identified within the PESTLE framework. The following should not be seen as a rigid set of lines of enquiry but examples for how external factors can be probed. It is not the intention to probe every external factor within this list, but to allow the natural group conversation to be guided should a relevant trigger spontaneously arise.

There are four potential ways that participants can be asked to think about external factors in the workshops. Facilitators should exercise their judgment as to which way may be appropriate to the flow of discussion, but should keep in mind that these workshops are focused on current needs and behaviours rather than asking participants to identify future needs and behaviours. As such, the first two items in the list below should be prioritised over the latter two.

1. Current understanding or experience of external factors, e.g. what do the Building Regulations currently require and how have they developed that understanding?
2. What difference the external factor makes to people at present, e.g. do they prefer a newer home because of the lower energy costs? How have they impacted their home development plans?
3. How people think external factors will or should change, e.g. will or should the Regulations require better insulation and more microgeneration?
4. How behaviour might change if the external factor goes in a particular direction in future, e.g. would people start to prefer an older home if the Regulations push up the capital cost too much?

This list of probes is likely to evolve over the course of the fieldwork based, on the experience of the facilitators.

External Factor	Triggers	Example Probes	Notes and motivation
POLITICAL			
EU Policy – influence on energy policy and consumer attitudes	• "Brussels" / EU / Europe • Energy in different countries (France, Germany, etc.) • European Climate Change targets (80% by 2050)	• What if much more of your electricity came from the continent (from an EU "supergrid")? • Do you think all EU countries should be working to the same targets? • Do you think the way you use heat energy at home is likely to change if the EU has more say in building standards or energy markets?	• Need to be very careful not to get drawn in to a debate that is mainly political, with no focus on energy. • How do participants feel about the EU's role (or UK's within Europe) in relation to heat energy?
National Policy – provision of guidance and direction to the public	• "The Government" (particularly DECC or re: responsibility for energy efficiency) • General comments on central political leadership • The Green Deal	• Why should the government be responsible for energy efficiency? • What should the Government do and would it be better if local councils took a bigger share of the work? • Do you think Government policy on energy affects the way you use energy?	• Need to be very careful not to get drawn in to a debate that is mainly political, with no focus on energy.
Local Policy – impact of localisation on climate change policy implementation	• "Big Society" • Local initiatives (e.g. "I got insulation through the council") • General comments related to value in local area/community	• Do you ever go to your local council for advice, help or guidance on energy? • Have you heard of any programmes offered by your LA for energy saving/home improvement? • How do you get information from your LA and would you prefer it another way? • What should local councils do and would it be better if took a bigger share of the work away from the Government?	• Need to be very careful not to get drawn in to a debate that is mainly political, with no focus on energy. • What appetite is there for a local approach to rolling out smart systems and heat?

External Factor	Triggers	Example Probes	Notes and motivation
ECONOMIC			
Income – average consumer income, income distribution and disposable income	• General comments about levels of household income • Comments about energy costs or the cost of energy-saving measures • Comments about domestic budgeting	• Do you have to make budgeting decisions related to using heat in your home? E.g. heat or eat? How do you decide? • Do you think the way you use energy would be very different if your income was 10% higher?	• Be sensitive to income related questions • How does income play a role in use of energy and appetite for smarter solutions?
Technology Costs & Technology Cost Structures – absolute and relative costs, relationship between upfront and running costs	• Comments on upfront costs of SSH technologies (insulation, boilers, etc.) • Comments on need for subsidy • “Payback” period	• Do you think about “payback” period when you buy products that you expect to save you money – how long it would take you to save enough money to cover the cost of purchase? • Do you think you’d be more likely to buy a product where running costs and payback were more clearly advertised? • What do you thing about the kinds of subsidies or loans that are available at the moment – from Government or energy company schemes?	• Which sorts of financial instruments are likely to work for different people?
Home Ownership Models – changes in tenure	• (Particularly renters’) comments on tenure-specific challenges	• How does renting/owning currently impact your decisions on how to use heat energy? • Would you be more likely to do more/less to save energy if you owned your home? • Would you consider paying more (to rent or to buy) for a home that was more energy efficient?	• How does tenure impact how people use energy and their appetite for change?
Fuel and Electricity Prices – domestic gas and oil prices, grid electricity prices	• Comments on cost of energy (electricity, gas, district heat or other heating fuel) • Comments related to saving money by conserving energy	• Do you feel that you are paying too much? • How do you think even higher prices might affect you in the future?	

External Factor	Triggers	Example Probes	Notes and motivation
SOCIAL			
Age – increase in aging population	• Mention of caring for elderly relative • Comments about preparing for retirement	• Do you have to do anything different due to an older person living in the home? What and why? • What changes might you make to your home or the way you use energy as you get older?	• Again, this may be a sensitive issue as it involves health. • Does age impact needs and potential take-up of smart solutions?
Education – rising levels of education	• Comments related to learning how to manage heat in the home • "I don't understand how my system works"	• Where did you learn how to do that? • Do you think that people should be taught in school how to manage their energy at home?	• Probe any levels of education, formal and informal
HouseholdSize – changing household sizes, rise of single person households	• Comments from people who live alone	• Do you do anything different with heating or keeping warm when you're by yourself at home? Why and what? • If applicable: How has the way you heat your home since you [married / had children / moved out of the family home]	• Key to our sampling hypothesis • Does a change in household composition lead to a significant change in needs/use?
TECHNOLOGICAL			
Energy Efficiency – advances in smart technologies, improved efficiencies for appliances, retrofit products and microgeneration	• Comments about buying products that can save energy • Insulation installations	• Do you ever pay more for something that is more energy-efficient? • Are there particular reasons why you [do not] choose more efficient technologies?	• What is the role of efficiency in a purchasing decision and how does this vary across different products
Diversity of Energy Generation – role of low carbon technologies	• Mention of renewables or microgeneration (e.g. solar panels) • Comments about where energy comes from (fossil fuels, power stations, etc.)	• Do you think about where your energy comes from? Do you care? • Would you like to generate your own energy? Is that likely to change in the future?	• How interested are people in where the energy comes from and how would they feel about local generation?
Electrification – impact of mass market electrification, increase in electricity demand	• Comments about electric heating • Comments from people off the gas grid	• What if you no longer had a gas supply? What if all your heat energy came from electricity? • Experiences of living without gas – pros and cons?	• Can people conceptualise a world where heat is primarily electric? What does that look like?

External Factor	Triggers	Example Probes	Notes and motivation
LEGAL			
Building Regulations – stricter standards for emissions reduction	• Comments related to current or past refurbishments • Comments related to new vs old homes • Challenges related to planning regime – e.g. conservation area	• What planning challenges have you experienced? • Energy conservation is part of the Building Regulations – do you think they have been successful in making newer homes more efficient? • (How) should energy concerns feature in Building Regulations in future?	• How do people feel that Building Regs help or restrict their needs related to heat energy?
Energy Sector Regulation – market controls, maintaining security of supply, reducing carbon emissions	• General comments/complaints about energy supplier • Comments about tariffs	• Are you aware of any energy-saving programmes run by your energy company? • What's your relationship with your supplier like? Different from relationship with other companies? Why? Could you imagine buying energy from other companies? • Do you understand how much you are charged or why prices rise? • Could you see yourself buying energy from a telecoms company such as BT or Virgin?	• What relationships do people have with their energy provider and can they imagine that changing in the future? • What would they like their energy company to be like?
Product Performance Labels – impact on consumer decision-making	• Comments related to buying items that normally have PP labels (e.g. white goods) • Comments related to not knowing which measures make biggest savings	• Do these labels make any difference to your purchasing choices? • Are they easy to understand? Do you ever think about the cost of an appliance over its whole life (taking into account the costs of purchase, energy use, maintenance/repair/ servicing, etc.)?	• What is the role of efficiency in a purchasing decision and how does this vary across different products

External Factor	Triggers	Example Probes	Notes and motivation
ENVIRONMENTAL			
External Temperatures – projected temperature increases, changes in heating and cooling demand	• "My home gets hot in summer" • Mention of experience living in a hotter climate (e.g. Mediterranean) • Mention of living with air conditioning or other cooling solutions	• What do you do when you're too hot? • What if your home was hotter in summer or hot more often? • What is it like living with [air conditioning / other mentioned cooling technology]? (If mention experience)	• How might people respond to a future where in-home space cooling is important?
Extreme Weather Events - changing weather patterns and consequences, impact on energy generation and consumer awareness	• Mention of flooding • Extreme weather experience (wind / rain / snow / heatwaves)	• Probe experiences of recent flooding? How did it impact you or those you know? • Are you concerned about future events like this? • How might you protect your home/family from something like this in future?	• Do people see a connection between extreme weather and their heat energy use? • Could such events motivate change?

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