Loughborough Design School

Design for Sustainable Behaviour: a conceptual model and intervention selection model for changing behaviour through design.

by

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Doctoral thesis submitted in partial fulfilment of the requirements for the award of

Doctor of Philosophy of Loughborough University

Abstract

This thesis is based in the research area of Design for Sustainable Behaviour (DfSB), a field which seeks to reduce the social and environmental impact of products in the use phase of their life cycle. There has been significant theoretical development in this area in recent years, leading to a proliferation of intervention strategies and design methodologies. However, there has been a recognised lack of a reliable means of selecting which intervention strategy to use in a given situation, and a lack of real world intervention case studies generating measurable medium-to-long term reductions in energy consumption. Addressing these gaps was a central focus of this research.

This thesis documents four distinct research phases; an extensive literature review, an in-depth user study of existing energy consuming behaviours and motivations, the development and trialling of design interventions, and the evaluation of the generated theories as a tool for designers.

Literature on domestic energy consumption, human behaviour, and approaches to changing behaviour was reviewed to establish the current level of thinking and to identify opportunities for further research. This guided the undertaking of the user study with a number of families in the East Midlands of the UK, which illuminated the relevant motivational goals, and highly routinized nature, displayed in many energy consuming behaviours. Over the course of this phase of the research journey a new conceptual model of behaviour in context was developed, and refined to create the Behavioural Intervention Selection Axis (BISA).

These theoretical developments were then applied to the generation of DfSB intervention concepts, one of which was selected and developed to a functional prototype stage. These prototypes were trialled in situ in family homes for an extended period, and achieved a significant change in behaviour and related energy consumption. Further evaluation of the BISA as a tool to guide designers was performed through a series of workshops with design students, which ascertained its usefulness in this respect.

Both the intervention development and trialling and the design workshops showed the conceptual model and BISA to be successful in providing designers with a reliable and useful means of selecting appropriate intervention strategies to change behaviour. In addition the intervention trial provided a wealth of qualitative insight into the way in which DfSB can effect behaviour, and the range of new motivational goals it can engender.

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Acknowledgements

"Is fánach an áit a bhfaighfeá gliomach"

Sean focail gaeilge.

This research was a journey, often into strange and foreign territories, but I consider myself exceptionally lucky to have had the company, support, and guidance of two wonderful and wise supervisors. Professor Tracy Bhamra and Doctor Val Mitchell have helped me at every juncture, calmed my panics, and allowed me the space to find my own path. I will always be grateful to you both.

This research was made possible by the provision of a studentship from the RCUK funded Low Effort Energy Demand Reduction (LEEDR) research project. I would like to thank the entire LEEDR team, but especially Dr Carolina Escobar-Tello and Dr Kerstin Leder-Mackley with whom I have worked so closely.

It is perhaps only now that I have left, that I can truly appreciate the how much I have gained from my friends and colleagues in Loughborough University. To be part of such a research community was an edifying privilege, but as importantly, it was also a lot of fun!

My immeasurable thanks to my parents, who have done so much to get me where I am today and encouraged me always - even if it meant not getting to see much of me for 4 years!

This thesis is dedicated to my beautiful wife Maryann, without your constant support this thesis would not exist, without your constant love I would not exist.

List of Publications

Journal Papers

Pink, S., Leder Mackley, K., Mitchell, V., Hanratty, M., Escobar-Tello, C., Bhamra, T., and Morosanu, R., 2013. Beyond Practice Theory: Applying the Lens of Sensory Ethnography to Sustainable HCI. *Sustainable HCI through Everyday Practices, A Special Issue of ACM Transactions on Computer-Human Interaction (ACM TOCHI).*

Conference Papers

Hanratty, M., Bhamra, T. and Mitchell, V., 2012. Digital Design for Sustainable Behaviour: A conceptual model to guide design intervention. *Using Technology to Facilitate Behaviour Change and Support Healthy, Sustainable Living Workshop,* HCI 2012, Birmingham, September 2012.

Conference Presentations

Hanratty, M. and Wilson, G., 2012. Designed for Sustainable Behaviour: Loughborough Case Studies. *Design for Sustainable Behaviour: Current Research, Future Directions,* Loughborough University, April 2012.

Hanratty, M., 2012. Digital Design for Sustainable Behaviour. *Design at the Front Edge,* Cranfield University, November 2011.

Conference Posters

Hanratty, M., 2011. Goal framed Digital Design for Sustainable Behaviour, 'Buildings don't use energy, people do.' *Conference on Domestic Energy Use and CO_2 Emissions in Existing Dwellings*, University of Bath, June 2011.*

*Best Poster Award.

Hanratty, M., 2011. Digital Design for Sustainable Behaviour: Making and breaking habits with cognitively aligned design. *Imagination Lancaster Design PhD Conference*, Lancaster University, September 2011.

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1. Introduction

1.1 Research Context

The UK has targeted an 80% reduction on 1990 levels of greenhouse gas (GHG) emissions by 2050 (HM Government, 2008). In order to meet this deadline, levels of domestic energy use must be reduced to a more sustainable level. Domestic energy use was responsible for 31% of UK energy use in 2010 (DECC, 2011), this energy is used for a number of activities, with approximately 53% of household carbon emissions being due to space heating, 20% due to water heating, 22% due to lights and appliances (HM Government, 2006). Energy use in the domestic sphere has continued to rise, even in the face of a continued reduction in national energy use over the last 20 years. Our homes are warmer and filled with more energy consuming gadgets than ever before as changing social norms create more energy intensive habitation patterns. While there has been a steady increase in the energy efficiency of domestic technologies, this has been offset by the continuously increased consumption of them (Druckman et al., 2011).

Domestic energy consumption and associated GHG emissions are dependent on many variable factors. Take, for example, space heating which is highly dependent on technical factors such as the type of dwelling, it's levels of insulation, the efficiency of the heating system, etc. , but is also determined by the behaviour of the occupants i.e. the temperature setting, the duration of heating, ventilation practices etc. (Druckman and Jackson, 2008). This complexity of variables can be mirrored across the whole range of domestic energy consuming activities, making it difficult to specify a "one size fits all" packaged solution. The various technical factors which impact domestic energy use (e.g. building fabric, appliance types, etc.) tend to embody significant capital investment on the parts of the owners and are unlikely to be changed in any systematic manner. Thus changing occupant behaviour is considered to be a fruitful area for energy reduction (Phillips and Rowley, 2011), a finding which is backed up by studies showing that occupant behaviour alone can affect domestic energy use by a factor of two in identical houses (e.g. Darby, 2006).

In this context, this thesis will examine the constituents of occupant behaviour with a view to creating behaviour changing design interventions in the future.

1.2 Aim and Objectives

The aim of this research is to determine effective strategies for the design of interventions that engender reduced energy consumption through behavioural change. In order to achieve this aim the following objectives are to be completed:

1. To identify the determinants of user behaviour through the evaluation of established behavioural theories from existing literature.
2. To develop the findings of the literature review into a conceptual model of behaviour in context.
3. To gather domestic energy behaviour data through a qualitative contextual study of real people.
4. To test the role of the conceptual model through the analysis of the qualitative contextual study.
5. To develop a reliable Design for Sustainable Behaviour intervention selection axis.
6. To concurrently test the Design for Sustainable Behaviour intervention selection axis suitability for use by designers.
7. To create a Design for Sustainable Behaviour driven prototype targeting reduced domestic energy consumption.
8. To test if the design interventions have been successful in reducing energy consumption though a combination of quantitative energy use measurements and qualitative contextual study.

1.3 Project Context

This research takes place within the context of the RCUK funded Low Effort Energy Demand Reduction (LEEDR) project. The primary role of this research investigation is to support the doctoral research student's original contribution to knowledge, of which this report and the investigations contained within form part of the first of three years of research study.

The secondary role of this work is to support Loughborough Design School's contribution to the LEEDR project. LEEDR is a multidisciplinary project based in Loughborough University and brings together researchers from:

- Department of Social Science,
- School of Civil and Building Engineering,
- Department of Computer Science,
- School of Electronic, Electrical and Systems Engineering,
- Loughborough Design School.

LEEDR aims to enable the design and evaluation of the next generation of intervention strategies that will help the UK towards achieving the 2050 CO_2 reduction targets. The project has a particular focus on the role of digital media in domestic energy consumption, both as a net consumer of energy and as a potential platform for energy demand reducing interventions. Although aspects of this doctoral research are aligned with the LEEDR project, the PhD itself was not beholden to this project.

The research conducted by this author has guided the work of other members in the LEEDR team, which in turn has been drawn upon in return. Figure 1-1 below outlines the relationship between the research done solely by the author, that done for or with the LEEDR project *by* the author, and those studies conducted by other LEEDR members which were drawn on for this research. The activities in the overlapping areas were primarily done in furtherance of the author's own research goals but also aligned with the research goals of the LEEDR project.

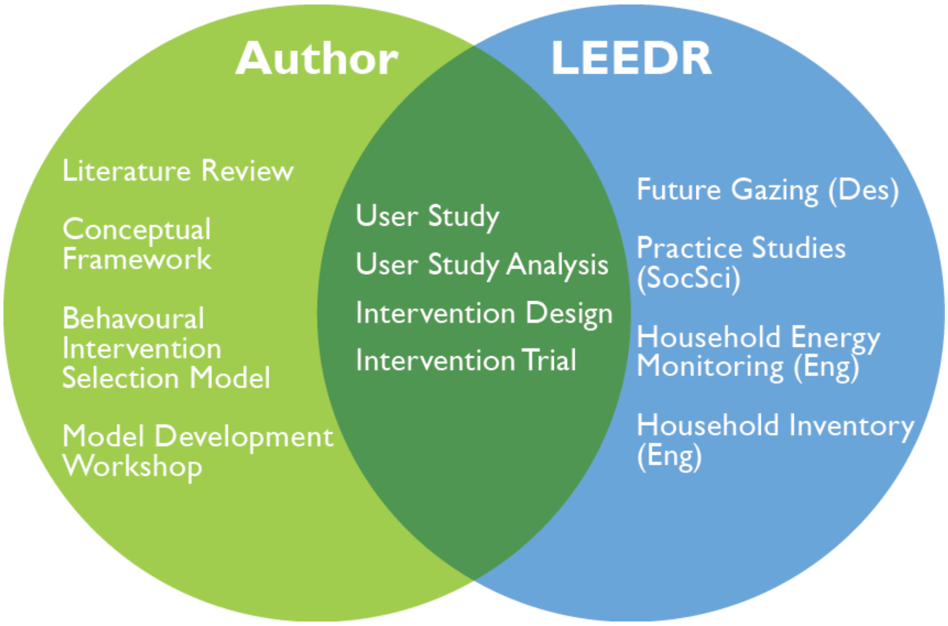


Figure 1-1. This research's relationship to LEEDR project.

1.4 Thesis Overview

This thesis is divided into nine further chapters, a brief overview of each is provided below. All Appendices referred to in the text are provided in separate binding.

Chapter 2: Literature Review

This chapter reviews and discusses the literature that has shaped this research. It begins by examining the impact of domestic energy consumption and exposing the central role of user behaviour in this. It goes on to explore the determinants of behaviour, the role of design for behaviour change, and the requirements for implementing it. It explores gaps in the current knowledge and highlights them for further investigation. Finally, a conceptual model of behaviour in context is drawn together from the literature.

Chapter 3: Research Methodology

In this chapter the research framework used to achieve the aims and objectives set out in Chapter 1 are outlined. The research purpose and strategy are discussed and defined, and requirements to maintain validity are identified. The scope of the subsequent studies is set forth and the sampling of participants is discussed. An outline of the main methods of data collection and analysis is presented.

Chapter 4: User Study

This chapter presents the main exploratory user study in this research. The research design is explained as are the details of realising the study. The analysis of the study is described and the findings are presented and discussed.

Chapter 5: Behavioural Intervention Selection Axis

This chapter discusses the development of a key theoretical construct which went on to frame and shape the subsequent research activities. The analysis of the User Study is used to refine the conceptual model drawn together from the literature and generate a Behavioural Intervention Selection Axis (BISA) to guide the design of DfSB interventions.

Chapter 6: Design Intervention Development

This chapter covers the employment of the BISA to generate a range of design intervention concepts. The designs are specified and their theoretical aspects are discussed. It describes the selection of one intervention to develop further and deals with the planning, development, and trialling of this design intervention.

Chapter 7: Design Intervention Evaluation

This chapter describes the intervention trial and evaluates the success of the design intervention. It provides a case by case outline of the effect of the intervention on participating families, and then analyses the success of the intervention in meeting established evaluation criteria.

Chapter 8: Validation of the BISA as a Tool to Guide Design

This chapter describes a series of design workshops with student designers which sought to ascertain the suitability of the BISA as a tool to guide design. It outlines the success of the methods used and discusses iterative development of the BISA based on learnings from this study.

Chapter 9: Discussion

This chapter presents the overall discussion of the research. The strands of discussion from previous chapters are developed further and emergent areas of interest explored.

Chapter 10: Conclusions and Future Work

Finally the overall conclusions from the research are presented. In this chapter the discussions and conclusions from previous chapters are positioned against the research aims and objectives. The overall contribution to knowledge is presented and the limitations of the research are discussed. Finally, future research activities are outlined and discussed.

2. Literature Review

2.1 Introduction

This chapter seeks to address following research objectives:

1. To identify the determinants of user behaviour through the evaluation of established behavioural theories from existing literature.
2. To develop the findings of the literature review into a conceptual model of behaviour in context.

The chapter begins by providing an overview of the primary constituents of the domestic energy landscape and highlights the important role of behaviour in energy use. It goes on to examine the determinants of behaviour and the theories pertaining to changing behaviour. Following on from this it reviews the modes of implementing behaviour change and the associated ethical concerns. An overview of the areas investigated can be seen in Figure 2-1.

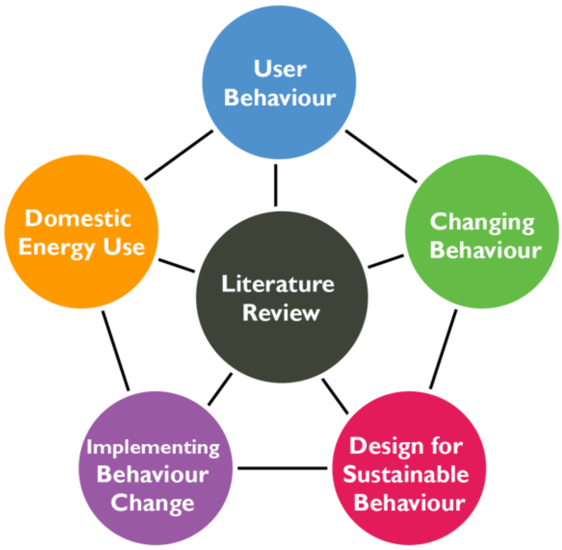


Figure 2-1. Overview of the Literature Review.

Finally, this chapter offers conclusions which guided the rest of the study and presents a conceptual framework of behaviour in context.

2.2 Domestic Energy Use

Before one can attempt to design energy saving products services or systems, it is vital to first understand the complex of factors that make up the domestic energy use landscape. According to Martiskainen and Coburn (2010) there are three main aspects of domestic energy consumption in the UK;

1. The structure and quality of the housing stock.
2. The energy performance of the appliances within those houses.
3. The behaviours of the householders themselves.

This research is mainly concerned with the behavioural aspects of energy use, but as will become apparent the contextual role of the first two criteria cannot be ignored. Behaviour is important for two main reasons. Firstly it has large impact on the amount of energy used in the home, for example, studies of identical housing stock have shown that occupant behaviour alone can lead to a variance in energy use of 2:1 in even new “low-carbon” dwellings (Darby, 2006; Gill et al., 2010). Secondly, changing behavioural norms are leading to a far more energy intensive habitation patterns, for example average heating levels have risen by 6°C over the last forty years and the amount of electricity used for light and appliances has more than doubled (Utley and Shorrock, 2008).

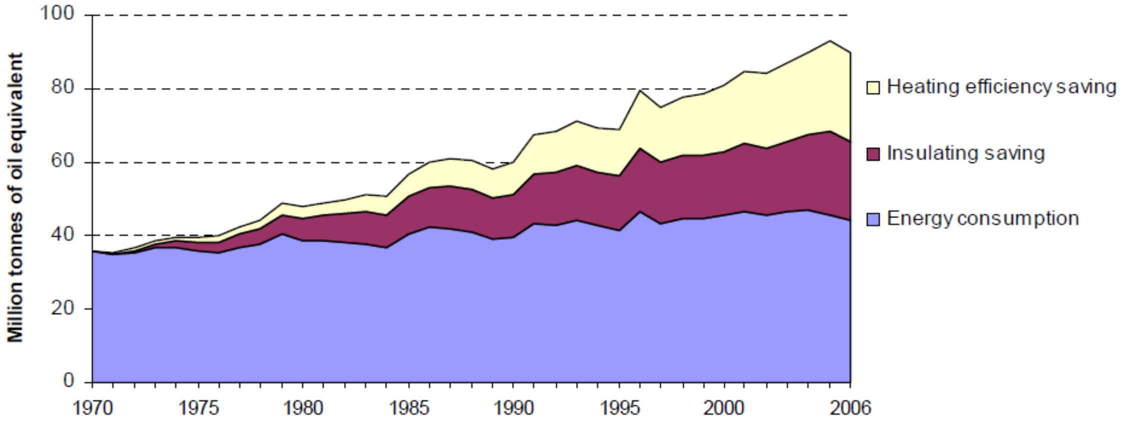


Figure 2-2. Energy savings due to insulation and heating efficiency improvements UK 1970-2006 (Utley and Shorrock, 2008) .

While technical efficiency measures are certainly part of the solution, the increase in consumption levels often has the effect of negating these gains. As evidenced by Figure 2-2 there have been large efficiency gains (c.50%) in the area of space heating in the last 40 years, but increased thermal comfort standards have caused a net increase in energy consumption in the same period. This "*rebound effect*" (Druckman et al., 2011) further pushes the focus towards occupant behaviour as the appropriate target for energy consumption reduction intervention.

2.3 User Behaviour

Behaviour can be defined as how a person behaves in a particular situation or under particular conditions (Cambridge Dictionary, 2015). Theories and models abound about the reasons human beings behave as they do, indeed the desire to understand and formalise our actions could be said to be one of the defining characteristics of our species.

In the context of analysing sustainable behaviour, Jackson (2005) maintains that there is scope to approach the existing models as heuristic frameworks for exploring and conceptualising user behaviour. Jackson (2005) also states that imperfect as they may be, they provide a framework from which to empirically test the strength of different contextual relationships in different circumstances.

2.3.1 The Decision Process

Costs and Benefits

Traditionally the most commonly used behavioural theory was that of the rational choice model (Maréchal, 2009; Cialdini and Martin, 2004; Biel and Thøgersen, 2007; Bruel and Egmond, 2007). This implies that we, as human beings, make decisions based on the weighing of the pros and cons of a given situation, and that, given the necessary information, will choose the "correct" path. This has been the prevalent model used by economists for centuries where we, the principal actors, have been reclassified as "*Homo oeconomicus*" (Maréchal, 2009; Earls, 2007). However, in more recent times, researchers have noted the limits to human decision-making and have reframed this under the umbrella term of "bounded rationality" (Jackson, 2005; Pichert and Katsikopoulos, 2008; Maréchal, 2009).

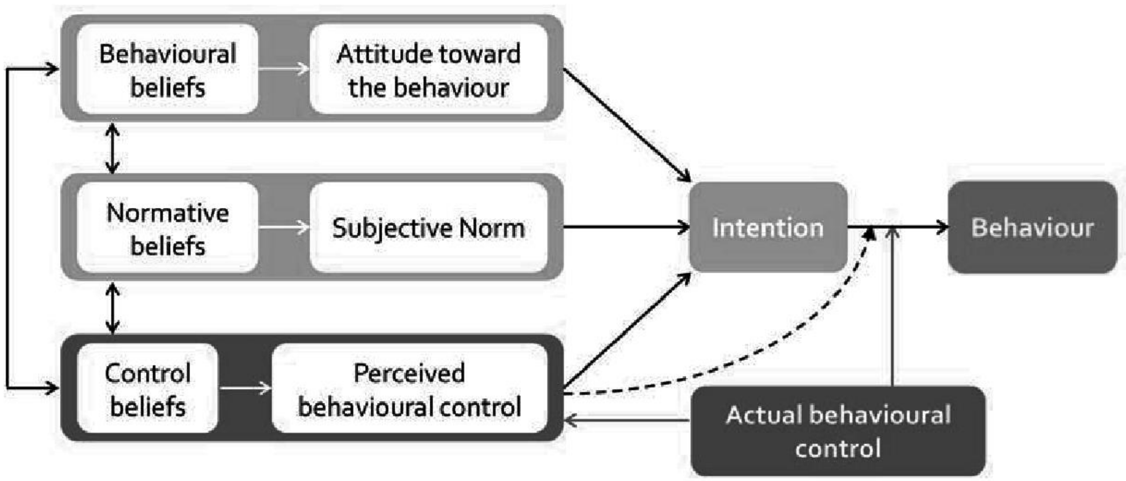


Figure 2-3. The Theory of Planned Behaviour (Ajzen, 1991).

In seeking to expand upon this, Ajzen's Theory of Planned Behaviour (ToPB) (1991) combines the rational choice model with others factors such as subjective Normative beliefs and the person's perceived behavioural control, Figure 2-3. This model also gives some weighting to external factors which affect the difficulty of performing behaviour as the Actual Behavioural Control variable. However as noted by Jackson (2005) and Tang (2010) the model doesn't include sufficient weighting for factors such as the Affective and Habitual sides of the decision making process. The relevance of these factors is explained comprehensively below.

Normative Values

Cialdini and Trost (1998) define social norms as *"rules and standards that are understood by members of a group, and that guide and/or constrain social behaviour without the force of law"*. They are context dependant so, for example, what might be acceptable behaviour in a public bar, might deemed less so in an exclusive restaurant. Internalised norms can be called Personal Norms (Schwartz and Howard, 1981) and operate in a similar manner. Paul Stern's (Stern, 2000) Value Belief Norms (VBN) theory model (Figure 2-4) explicitly focuses on the value and moral driven basis for environmental behaviour. This has been found to be accurate in predicting low cost environmental behaviour and predicting good intentions i.e. separating waste for curb side recycling, but far less reliable when dealing with actions with a higher behavioural or financial cost i.e. reducing car use (Steg and Vlek, 2009).

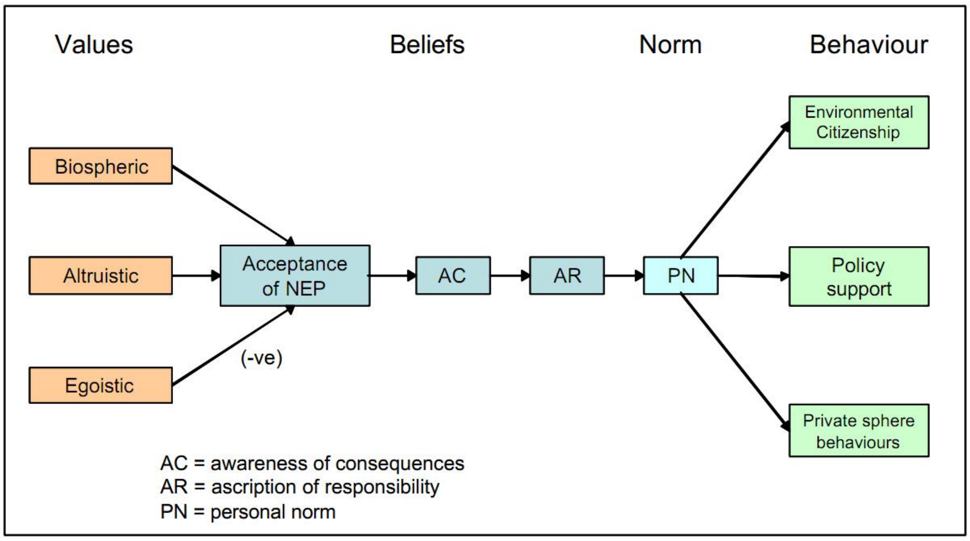


Figure 2-4. Values Beliefs Norms Behavioural Model (Stern, 2000).

Affect

The third main motivational domain is that of affect (Steg and Vlek, 2009). Jackson (2005) clearly illustrates the role affect can play in this example:

> *"I decide to keep, rather than give away or have put down, an elderly cat who has suddenly begun to urinate in my study and cause me untold frustration and extra housework, not because I have totted up the costs and benefits of keeping it, but because I have an overriding affection for another creature who has shared a part of my life with me."*

Implicit in this example is the extra environmental impact of keeping the animal e.g. cleaning products, replacing soiled furniture, trips to the vet etc, but these concerns are probably not even filtered into the decision making process because of the over-ride of Affection. Dittmar's (1992) theory proposes that material possessions fulfil three functions; instrumental, symbolic, and affective. Steg (2005) tested this hypothesis on car use and found the symbolic and affective aspects to be dominant to the instrumental, clearly showing this approach offers a promising perspective on individual motives to buy and use goods.

Integrated Model

As can be seen from the selection of behavioural models shown above, defining the broad spectrum of causes leads to an increasingly complex web of variables. Given the unpredictability of the relevant variables , adherence to a particular detailed model or focusing on correlates of a composite environmental behaviour may exclude other more relevant variables (Lindenberg and Steg, 2007) .

Thus, Lindenberg and Steg (2007) propose Goal Framing Theory, which states that in a given context, the decisions people make, particularly in the early phase of a behaviour, are driven by a combination of three goal frames:

- Hedonic - to feel better right now
- Gain – to guard or improve one's resources
- Normative – to act appropriately

In every decision all three goal frames are present but one (or two) will be dominant, as in this example; "I know I should go downstairs and turn off the light in the kitchen, but I'm so comfortable in bed right now". In this case the hedonic goal frame is dominating both the intention to act appropriately and to guard ones resources.

Lindenberg's (2005) notion of "smart norms" differs from the established understanding of norms discussed earlier. Instead it is simply to act appropriately; the individual searches the environment for cues to determine "what behaviour is appropriate in this situation?"(Lindenberg and Steg, 2007). This acknowledges the role of the contextual situation in framing the normative standards at that moment.

2.3.2 Contextual Factors

Context as a backdrop

Inherently all personal behavioural motivations exist in a given context, the constraints and freedoms of which define their manifestations (Steg and Vlek, 2009b). Stern identifies many factors which populate the contextual domain, including;

- attributes carried from birth (e.g., cultural, religion, class)
- acquired capabilities (e.g., education, skills)
- situational attributes (e.g., rural or urban, ownership of vehicles and appliances),
- interpersonal influences (e.g., persuasion, modelling)
- legal and institutional factors,
- public environmental policies ,
- economic variables (e.g., income, availability of goods and services)

(Stern, 1999; Stern, 2000)

In a behavioural sense, contextual factors are said to operate on behaviour in four distinct, but not necessarily exclusive, ways. These can all be illustrated through the paradigm of a single practice, in this case consumer recycling.

1. They can directly facilitate or constrain behaviour, i.*e. one cannot recycle without the availability of recycling facilities.*
2. The relationship between contextual factors and behaviour can be mediated by motivational factors like attitudes and norms, *i.e. introducing convenient recycling facilities may engender more positive attitudes to recycling and thus higher levels of compliance.*
3. They can moderate the relationship between motivational factors and behaviour, *i.e. a strong desire to recycle can only be realised with the provision of*

facilities, conversely, the provision of facilities may only promote recycling to those already concerned about the environment

4. In the context of Goal Framing Theory, contextual factors may determine which motivations most strongly affect behaviour, *i.e. normative goals may drive action when convenient facilities exist, while hedonic goals may be strongest when recycling requires more effort.*

(Steg and Vlek, 2009)

However, Steg and Vlek (2009) also state that there is a need for more study on the impact of contextual factors on environmental behaviour's relationship with motivational factors. This notion of the contextual impact has been strongly realised in Design Studies, where researchers like Donald Norman (1990) have stressed the role objects' "affordances and constraints" have not just on our ability to use them, but our perceived ability to use them and our desire to use them.

In the domestic environment, products and their locations comprise the physical context, but the way we use them is driven by the myriad of variables unique to each. Anthony Dunne's (2006) more design-centric definition of behaviour is *"a narrative experience arising from the interaction between our desire to act through products and the social and behavioural limitations imposed through their conceptual models".* In this light it may be more appropriate to view Stern's view of the contextual domains as being the macro context, and the range of individual products and their locations as constituents of a personalised micro context.

Context as centre-stage

There is an increasing interest in the role of our immediate context as a major factor in behaviour (Dolan et al., 2010; Earls, 2007; Lindenberg and Steg, 2007). This derives from an increased understanding of how our day to day decisions are made, or as Earls (2007) put it, a greater understanding of our "lazy brain". Central to this is the work of Daniel Kanhneman who has demonstrated that our thinking is not as rational as it seems to us, and that much of what we consider to be rational thought is indeed a form of post rationalisation or self-deception (Dolan et al., 2010; Earls, 2007). Instead, our behaviour is largely driven by contextual cues and the manner in which the information is presented to us.

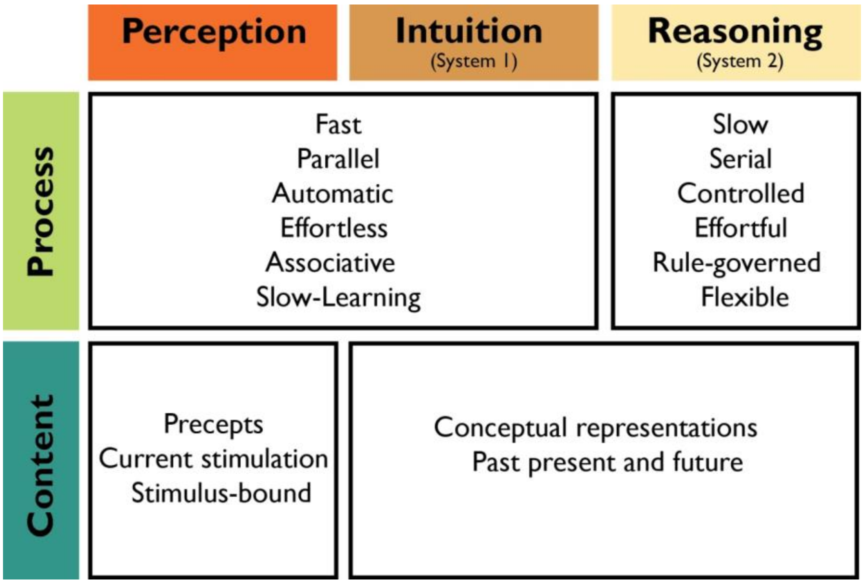


Figure 2-5. Kanhneman two-stage model, Kanhneman cited in Earls(2007).

The key tenet of this model is that our decision making is largely a) outside out of rational consciousness, and b) highly influenced by the framing of the problem. The rational mind offers a more systematic approach but is limited in its capacity, while the automatic mind can process many things simultaneously but *"takes short cuts and has ingrained biases"(Dolan et al., 2010)*

"In a rational-agent model, the agent's mind functions just as she would like it to function. Framing effects violate that basic requirement: the respondents who exhibit susceptibility to framing effects wish their minds were able to avoid them." (Kanheman, 2002)

This framing effect is derived not just from the way the information is presented but also by the brain seeking previously experienced patterns in the contextual cues (Tversky and Kahneman, 1974). It does this because it reduces the work load of rationalising and consciously processing all the available information in a given context which would be slow and effortful. As can be seen in Figure 2-5, Perception and Intuition are linked to fast, effortless, and associative processing, while the slower, more effortful reflective aspects of reasoning occupy a smaller portion of mental bandwidth. By thus using a range of cognitive and emotional heuristics to interpret a situation the brain can make immediate and often unconscious choices (Maréchal, 2009).

2.3.3 Habits

As can be seen in Kanheman's work (Kanheman, 2002; Tversky and Kanheman, 1974) the mind relies on past contextual experience and heuristic judgements to instantly interpret a given situation. This recognition and interpretation will often lead to automatic unconscious action by the individual and this is the realm of habitual behaviour. Much energy related behaviour is habitual in nature and is often built into context dependent routines (Martiskainen and Coburn, 2010), indeed one study estimates that 45% of our daily actions are habitual in nature (Verplanken and Wood, 2006). Jackson (2005) regards habits as cognitive scripts which reduce the cognitive effort required by routine decisions whose rationality has already been determined.

In effect, when we encounter a new situational context we intuitively use our both our reason and our recall of similar experiences to determine an action, if this action is successful and achieves our goal we are likely to use it again when we next encounter the same situation (Verplanken and Aarts, 1999). While our choice may not have been the optimum possible response, if successful it will have at least met our minimum acceptable criteria and we will be unaware of a means of achieving a better solution (Jackson, 2005; Verplanken and Aarts, 1999). If we continue to encounter the same situational context without gaining improved practical knowledge, it is likely that the action will continue to strengthen in automaticity and persist as habit.

Frequency and duration of repetition are important factors in the development of habits (Jackson, 2005) , and an act which is repeated daily i.e. airing a bedroom in the morning, will be far more entrenched and automatic that one that is only performed once a year . Going further, Verplanken and Orbel (2003) state that when a goal associated with a habit is activated, specific cue-response links become more accessible in the brain. Thus, encountering such a contextual cue automatically triggers the habitual response. *"In other words, whereas new behaviour may follow from conscious decision making, the formation of a habit implies the delegation of control over the behaviour to the environment"* (Verplanken and Orbell, 2003). This concept is extremely pertinent to designers, as the products they design become, in effect, the constituents of a given environment or context.

As stated, habit is dependent on a constant context (Verplanken and Aarts, 1999) and thus is likely to continue in the absence of significant contextual change or a distinct cognitive effort (Verplanken and Aarts, 1999; Martiskainen and Coburn, 2010). In addition it is necessary to break down old behaviours , by either contextual or pedagogical change, before new ones can develop (Stern, 2000) .

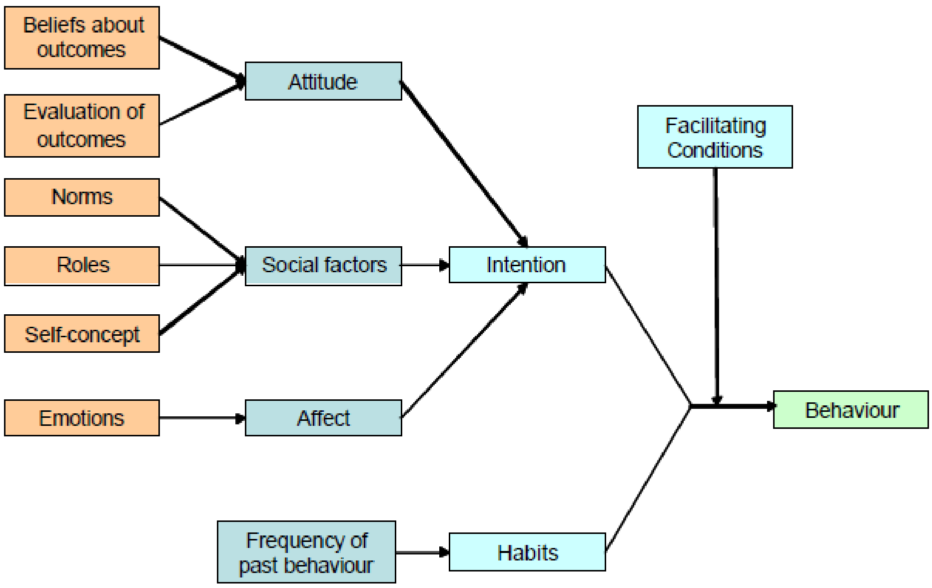


Figure 2-6. Triandis' Theory of Interpersonal Behaviour, cited in Jackson(2005).

Having long being largely ignored for it's apparent complexity or what Jackson (2005) terms it's lack of parsimony, Triandis' Theory of Interpersonal Behaviour (1977), see Figure 2-6 has recently gained a lot of currency in environmental behaviour literature (Jackson, 2005; Bruel and Egmond, 2007; Verplanken and Aarts, 1999; Martiskainen and Coburn, 2010; Steg and Vlek, 2009; Tang, 2010), in part because it recognises the role played by social factors and emotions in forming intentions. But importantly he also gives equal measure to the role of habits in determining whether or not that intention translates into behaviour; that is behaviour which can only occur through the facilitating conditions (i.e. context).

2.4 Changing Behaviour

2.4.1 Strategies for Behaviour Change

As described previously, behaviour can be shown as the product of individual's knowledge, attitudes and beliefs interfacing with a given physical and societal context. It thus follows that strategies to change environmental behaviour have historically been grouped to target both of these areas and can be termed to be informational, i.e. aimed at changing knowledge, attitudes, and beliefs, or structural i.e. changing the context (Steg and Vlek, 2009). It should be noted however, that there is an element of cross over between informational and structural strategies as often one begets the other through implementation (Steg and Vlek, 2009). Also both of these types can be further divided into antecedent strategies, i.e. seeking influence before the behaviour has occurred, or consequence strategies ,i.e. changing the consequence following the behaviour (Steg and Vlek, 2009; Abrahamse et al., 2005). The various strategies and their natures are described in Table 2-1.

Table 2-1. Behaviour Change strategies with indication of main bias.

Behaviour Change strategies with indication of main bias.	Information	Mixed (Informational and Structural)	Structural
General Information	This consists of information aimed at increasing the actor's knowledge of the environmental impact of their actions and/or behavioural alternatives (Steg and Vlek, 2009; Abrahamse et al., 2005).		
Persuasive Information	Information aimed at leveraging an individual's susceptibility to persuasive argument. It can rely on a number of tools such as framing and rhetoric, but is limited in scope by the varied nature of audience (Steg and Vlek, 2009)		
Normative	Uses social support and role models to strengthen social norms, and to inform people about the perceptions, efficacy and behaviour of		

Information	similar others. Information needs to be targeted to provide meaningful comparison (Steg and Vlek, 2009; Abrahamse et al., 2005)
Tailored Information	The provision of information specific to the context and abilities of an individual. Requires considerable time and resources to ascertain the operant conditions (Abrahamse et al., 2005; Abrahamse et al., 2007).
Goal Setting	Goal setting and Commitment strategies require the individual to engage in a commitment either directly with a third party or with themselves facilitated by a third party (Abrahamse et al., 2005; Steg and Vlek, 2009; Abrahamse et al., 2007).
Feedback	The provision of a performance indicator based on the results of an act through which people can make associations between their actions its consequences and potentially make changes to their behaviour. (Abrahamse et al., 2005; Abrahamse et al., 2007; Steg and Vlek, 2009; Darby, 2006).
Rewards	Rewards can be either financial or non financial and seek to illicit behaviour change for personal gain. In environmental literature rewards are considered preferable to penalties as they are more likely engender the positive attitudes needed for sustained change (Steg and Vlek, 2009). However in behavioural economics, loss is considered a stronger motivator in the short term(Dolan et al., 2010)
Enabling	The availability and quality of products and services may be altered via changes in physical, technical, and/or organisational systems

structures.	which can enable environmentally superior behaviour in the individual to occur, such as the provision of bicycle lanes in the city centre (Steg and Vlek, 2009).
Proscriptive regulation	The limiting or banning of environmentally detrimental behaviour or products can force a change in behaviour (Steg and Vlek, 2009) though may meet with strong resistance even if the final impact on quality of life is not too severe. (Steg, 2008)

Most of the above strategies can be delivered through a variety of channels at a broad range of intervals and times and often as not in conjunction with other strategies (Abrahamse et al., 2005). This variance goes some way to explaining the large range of success some of these measures have historically had in reducing energy consumption in experimental trials. For example, in a large review of energy use reduction intervention measures Raw and Ross (2011b) found that similar interventions gain very different savings (e.g. -5% to 23%) depending on the nature and timing of the intervention and whether it was a stand-alone or compound strategy.

Persuasive Aspects of Behaviour Change Strategies

The variance in success of previous behaviour change interventions illustrate that it is often not so much the strategy itself which effects the change but rather the way in which it is delivered to the individual which matters. Dolan et al (2010) have tried to highlight some of the important aspects of this with the "context model of behaviour change" in the MINDSPACE study (Table 2-2). The intervention design criteria they developed is not concerned with the strategy type but rather with the manner in which the intervention should be presented to the individual.

Messenger	we are heavily influenced by who communicates information
Incentives	our responses to incentives are shaped by predictable mental shortcuts, such as strongly avoiding losses
Norms	we are strongly influenced by what others do
Defaults	we 'go with the flow' of pre-set options
Salience	our attention is drawn to what is novel and seems relevant to us
Priming	our acts are often influenced by sub-conscious cues
Affect	our emotional associations can powerfully shape our actions
Commitments	we seek to be consistent with our public promises, and reciprocate acts
Ego	we act in ways that make us feel better about ourselves

Table 2-2. MINDSPACE contextual behaviour guide (Dolan et al., 2010).

The MINDSPACE model often directly overlaps with the existing strategies mentioned in Table 2-1 , particularly the concepts of incentives, norms, and commitments, but importantly it considers the effect of the overall context of the intervention interfacing with the individual (Dolan et al., 2010). For example, comprehensive energy information could be sent through the letterbox as a flyer, but is likely to be immediately consigned to the bin with the rest of the "junk" mail, however a person from the local council calling to the door with the same information would have a far greater impact on the householder. In addition the concepts of salience, affect, and ego highlight the need to clearly understand the knowledge, attitudes and motivations of the people the interventions are targeted at.

Further work has been taken on leveraging peoples susceptibility to persuasion by Paul Cialdini (Cialdini, 2001; Cialdini and Martin, 2004; Cialdini and Trost, 1998) who has developed an experimentally proven list of six principles of social persuasion based on what he terms humans' innate "fixed action patterns" (Cialdini, 2001). These, he maintains, have similarities to genetically coded behaviours such as courtship dances in birds in that they are effectively pre-programmed into us as social animals. His Six principles of social persuasion can be seen in Table 2-3. Encouragingly, there is significant overlap with the MINDSPACE criteria which was derived from largely different sources.

Principle	Description
Scarcity	People typically overvalue things that are rare, dwindling in availability or difficult to acquire
Authority	People are more easily persuaded by individuals perceived to be legitimate authorities
Social Proof	People often look to the behaviour of similar others for direction about what choices to make
Liking	People prefer to say “yes” to those they like
Reciprocity	People feel obligated to repay, in kind, what has been given to them
Consistency	People feel strong pressure to be consistent within their own words and actions

Table 2-3. Paul Cialdini’s (2001) Six principles of social persuasion.

2.4.2 Strategies for Habit Change

Veerplanken and Wood (2006) consider habit breaking interventions to fall into three categories: downstream, downstream with contextual change, and upstream. Upstream seeks to prevent the “bad” habit forming by anticipating it and directing behaviour elsewhere , and downstream is the application of informational strategies after the event (akin to consequence behaviour change strategies). However “*downstream approaches will be most successful when they are paired with environmental changes that disrupt existing habits”*.(Verplanken and Wood, 2006).

These “*environmental”* or contextual changes can occur in either the macro (i.e legislative) or micro (i.e. physical design of a product) context and succeed by either making the habit impossible, changing the experienced outcome, or by stopping the automatic mental processes running (Zachrisson and Boks, 2010). This type of design innovation led change was classified by Robertson (1967) into three categories:

- Continuous Innovation – minor alteration to an established product, e.g. region specific coffee beans.
- Dynamically continuous innovation – creation of new products or significant alteration of an existing one, e.g. instant coffee powder.

- Discontinuous innovation – the introduction of completely new disruptive product types, e.g. Red Bull energy drinks.

The closer you move towards discontinuous innovation, the more the modes of interaction (and thus the potential contextual cues to habitual behaviour) become changed from the original, thus offering more scope to build a new habit in the old one's place. In terms of domestic energy use, reimagining the habitual patterns of interface between occupants and energy using appliances offers fertile ground for reducing consumption levels, particularly as the product/appliance is often directly in the focus of the user in a given task (Zachrisson and Boks, 2010). *"One of the most effective aspects to change is the way the user interacts with the product. The more novel the interaction with the product is, the higher the chance of being able to break the habit". (Zachrisson and Boks, 2010)*

The success of these new interactions is also highly context dependent, because an interaction which works brilliantly in an office setting might not fit into domestic space or lifestyle or vice a versa. Recognising this, Midden et al.(2007) draw attention to the importance of the location and the ergonomics of any product seeking to change behaviour and the lack of research on the subject. "*Situational factors such as noise or sunlight can limit the readability of the devices. Ambiguous dialogues or unclear symbols may hamper message understanding, and sources with low access will require more motivation. Unfortunately, these factors have rarely been manipulated, measured, or reported."* (Midden et al., 2007).

2.5 Design for Sustainable Behaviour

In the same way as our behaviour is shaped by the context we act in, the design of the products, services, and systems (PSS) which populate it determine how we use them (Norman, 1990). The goods and services available to us effectively create "scripts" of usage in which our possible roles are defined in scope (Jelsma and Knot, 2002; Ingram et al., 2007). In terms of domestic energy use, which is often determined by user behaviour (Bhamra et al., 2008), both our homes themselves and the products and appliances within all set forth a range of overt or tacit scripted interactions which strongly shape the manner in which we do or don't use them.

Recognising this, the nascent field of Design for Sustainable Behaviour (DfSB) aims to apply strategies that intentionally shape behaviour towards sustainable practices (Bhamra et al., 2008; Lilley, 2009; Elias et al., 2008a; Lockton et al., 2008). It employs a variety of approaches ranging from utilising the informational and contextual agency of the PSS to reshape user knowledge, behaviour and habits, to redesigning the PSS to more efficiently match the way the people already actually use them (Jelsma and Knot, 2002; Bhamra et al., 2008; Lilley, 2009; Wilson, 2010; Wever et al., 2008; Rodriguez and Boks, 2005). As Lockton et al (2009) put it, this changes the role of the designer from facilitator to sustainable activist and requires new skills and knowledge.

Central to the field is the study of how people actual behave and the underlying reasons and motivations thereof. This approach to design can be termed User Centred Design (Tang and Bhamra, 2008b; ISO, 1999) or Human Centred Design (IDEO, 2009) or, more pointedly, User-Centred-Eco-Design (Elias et al., 2008b). Bhamra et al (2008) have shown that there is as yet no single correct approach or methodology to DfSB and several applicable models have thus far been put forward.

2.5.1 DfSB Models

The Theoretical Minimum

Elias et al's work is aimed at moving Eco-design away from a focus mainly on the supply side of PSS design, i.e. the materials – manufacturing - transport, and towards the use phase of PSS (Elias et al., 2007; Elias et al., 2009). They propose a method of quantitatively evaluating the impact of behaviour by first isolating the theoretical minimum amount of energy required to perform a function , then calculating the intrinsic losses determined by the build of the product, and finally calculating user related losses or the losses due to user behaviour.

This method can easily be illustrated by looking at the design of a kettle, in this case the theoretical minimum is the amount of energy required to heat water by one degree Celsius multiplied by the required range of temperature. Secondly, the intrinsic losses include the efficiency with which the kettle converts energy to heat and transfers it to the water, the minimum amount of water the kettle must be filled with and the loss of transferred heat from poor insulation. Finally the user related losses referred to include overfilling the kettle, forgetting to use the water when first boiled or deliberately letting it cool down to the desired level, discarding of hot water in favour of fresh, etc. (Elias et al., 2007; Elias et al., 2009; Elias et al., 2008b).

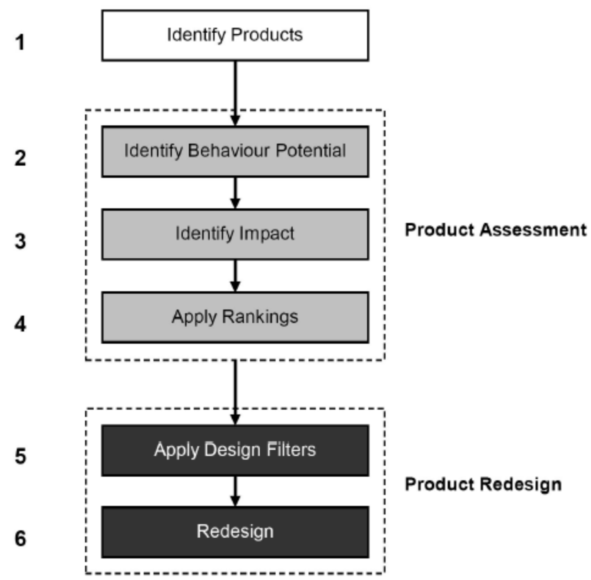


Figure 2-7. Elias et al's Six Step Process to product assessment and redesign.

Having the determined these three conditions the designer can apply design filters to the relevant technical and behavioural aspects which enforce use efficiency. Figure 2-7 shows Elias et al's Six Step process, which illustrates how once the impact of the problem behaviours has been ranked the most relevant can then be targeted with appropriate design strategy . One of the main factors in the model is that the authors describe *"a range of good and bad behaviours with good behaviour being more energy-efficient than bad".* This can lead to misinterpretation of the users actual goals in using the product (Rodriguez and Boks, 2005) and lead to further misaligned behaviour/use/efficiency scenarios. For example, users may boil water then leave it to cool down, rather than assuming this is due to forgetfulness and designing in an audible reminder, it may be that they require water below boiling point for herbal tea; this would require a completely different design intervention. In addition the model does not cope well with complex subjective use problems such as efficiently maintaining thermal "comfort" in disparate multi-person homes.

The Delft model

Wever et al (2008) move closer to gaining an understanding of the multivariate user and contextual factors influencing PSS use by placing the interaction in a larger physical and societal field (Figure 2-8).

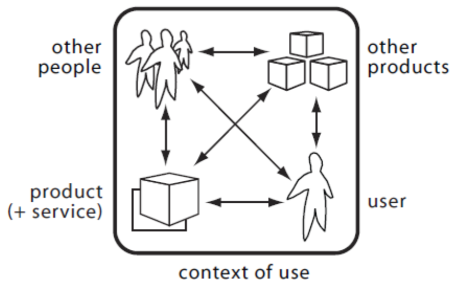


Figure 2-8. Wever et al's (2008) extended model of Human/PSS use context.

This recognises that the ways PSSs are used are strongly influenced by other people, other products and services available (or not) the characteristics of the user(s) and by the nature of the PSSs themselves. It follows that to design for sustainable behaviour one should investigate all these factors.

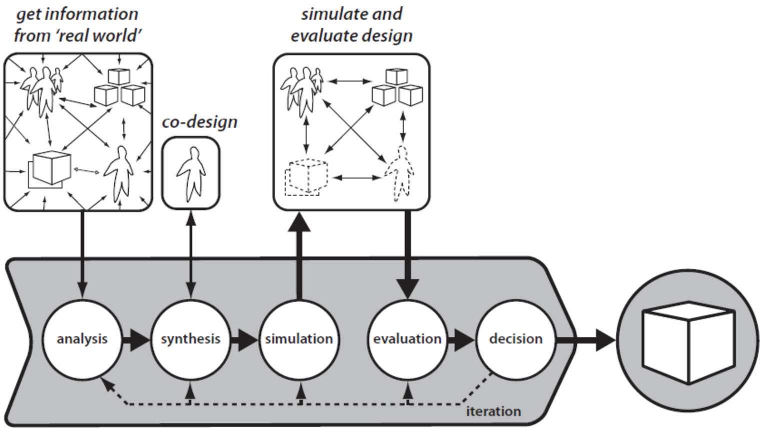


Figure 2-9. The User Centred Design cycle (Wever et al., 2008) .

An iterative user centred design approach (Figure 2-9) will ensure the delivered functionality of the PSS matches the users' desired functionality, the first and most critical role of a design seeking to effect behaviour change in a free market. The second strand of the Delft approach (Figure 2-10) is to include an appropriate range of persuasive or behaviour inducing strategies to shift the actual use to a sustainable level. These approaches have been drawn from a wide literature base including Jelsma et al's (2002) notion of scripts and Lilley's (2007) approach .

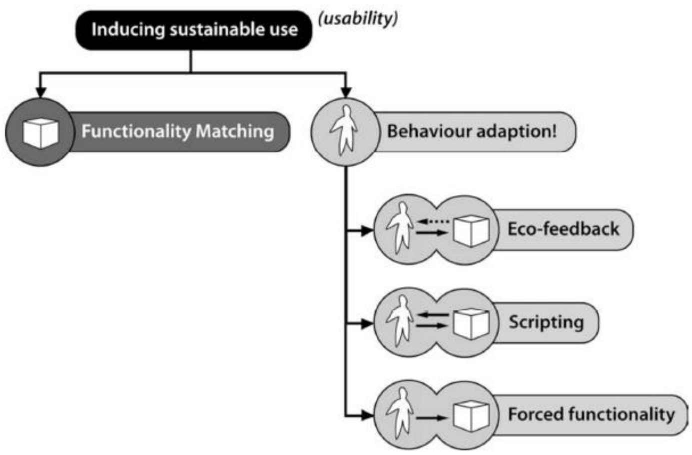


Figure 2-10. Wever et al's (2008) dual branched typology of behaviour inducing design strategies.

The Loughborough Model

Lilley (Lilley, 2009; Lilley, 2007) argues that there is an axis of influence in the interface of user and product that determines where the decision making power lies (Wilson, 2010). As seen in Figure 2-11, this runs between two poles, one end is User Agentive where the user has the power and ability to use the product in whatever way they wish. The other pole is Technological Agentive where the product's form and functional capabilities donate the mode of use entirely. Lilley puts forth a system of utilising the nature of this relationship to introduce appropriate behaviour changing or moderating features dependent on the level of user control deemed appropriate to the situation.

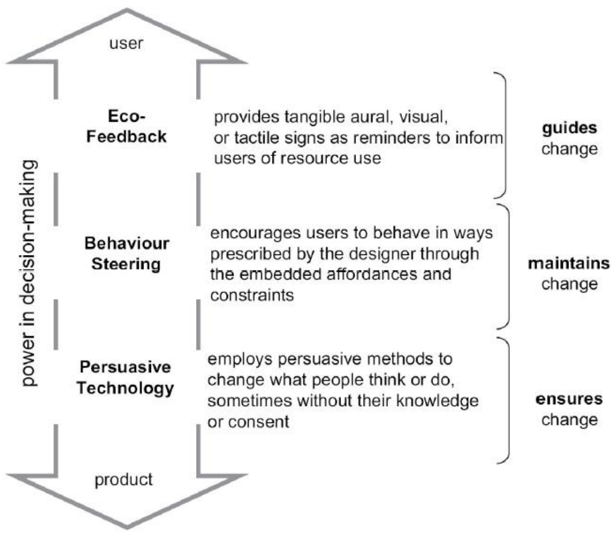


Figure 2-11. Lilley's Axis of Influence (2009).

Towards the User Agentive end of the scale Eco-feedback can used to potentially guide change by informing users of resource use and allowing them to moderate their use pattern accordingly if they choose (passive intervention). In the middle of the axis, Behaviour Steering encourages the users to behave in certain ways defined by the designer by embedding affordances and constraints into the physical or functional design (assertive intervention). Finally at the Technological Agentive end Persuasive Technology like intelligent context aware technologies that change what people do or think can be used, whether or not the user is aware of it (coercive intervention).

While it could be argued that all designed objects contain affordances and scripts (Norman, 1990; Jelsma and Knot, 2002), what is different in this type of approach is the designers intention. This raises ethical issues (Fogg, 2003; Lilley, 2009) which will be discussed in section 2.6.4.

Consumption Behaviour and Design Interventions Framework

Tang and Bhamra (2008a) have sought to integrate Lilley's (2009) axis with behavioural theory by integrating it with Triandis's (1977) Theory of Interpersonal Behaviour (ToIP) and Anderson's(1982) theory on the acquisition of cognitive skill. Thus, the ToIP is in effect in the early stages of a new behaviour occurring, or in what Anderson terms the Declarative Stage. This is when a person is encountering a new situational context and determining the "best" course of action. As Tang and Bhamra (2008a) put forth in Figure 2-12, it is at this point user-agentive interventions such as Eco-Information, Eco-Choice, and Eco- Feedback provide enough information for the person to determine the "correct" or most environmentally beneficial path.

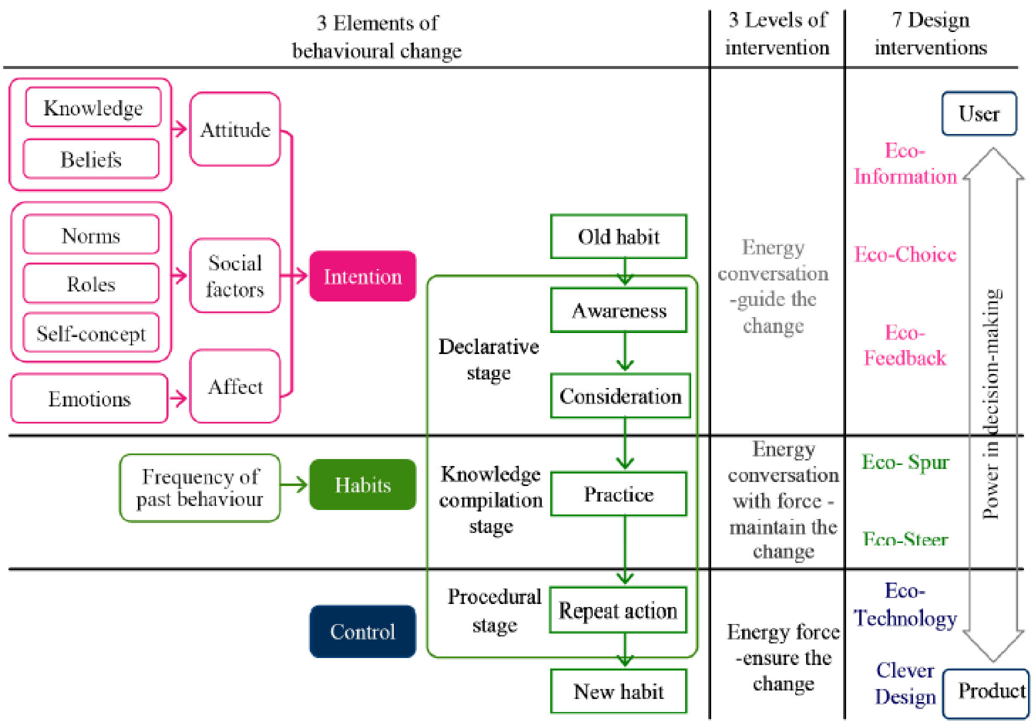


Figure 2-12. Consumption Behaviour and Design Interventions Framework.(Tang, 2010)

As the behaviour becomes more established and enters the Knowledge Completion Stage (Anderson, 1982) the user has determined the operational procedure and merely seeks to implement it. At this stage more forceful interventions like Eco-Steer and Eco-Spur are called upon to redirect behaviour (Tang and Bhamra, 2008a). Finally, when a behaviour is fully automatic and without conscious thought it is in the Procedural stage (Anderson, 1982) and needs a technology-agentive intervention to force the change such as Eco-Technology or Clever Design.

Zachrisson and Bok's Axis

As seen above Tang and Bhamra (2008a) have expanded Lilley's(2009) list of three intervention types into seven specific Eco-approaches along the same axis. While these are more enlightening as to the nature of the intervention, they are perhaps somewhat constraining in the acuity of their definition and more generalist definitions of the aim of the interventions may be more useful to the designer. In a review of various DfSB methodologies Zachrisson and Boks (2010) have taken an overview of this user/technology axis of control (Figure 2-13) including intervention strategies as developed by several different authors (Jelsma and Knot, 2002; Lilley, 2009; Lockton et al., 2009; Tang and Bhamra, 2008a) and complied a more goal orientated intervention axis.

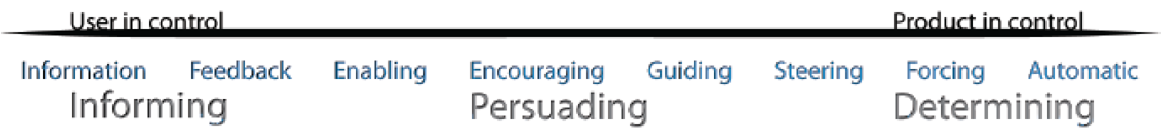


Figure 2-13. User/Product Axis of Control (Zachrisson and Boks, 2010).

Lidman et al's Model

Lidman et al (2011) have also put forward a model for categorising design strategies for Design for Sustainable Behaviour. As show in Figure 2-14, their model is elegantly presented, and explicitly differentiates between design strategies that change behaviour and those that do not, i.e. functionality matching. The model also differentiates between those strategies which motivate the user to engage in the target behaviour, and those which constrain the user from engaging in behaviours other than the target behaviour. Aside from these considerations the model is not significantly different to others proposed in the literature.

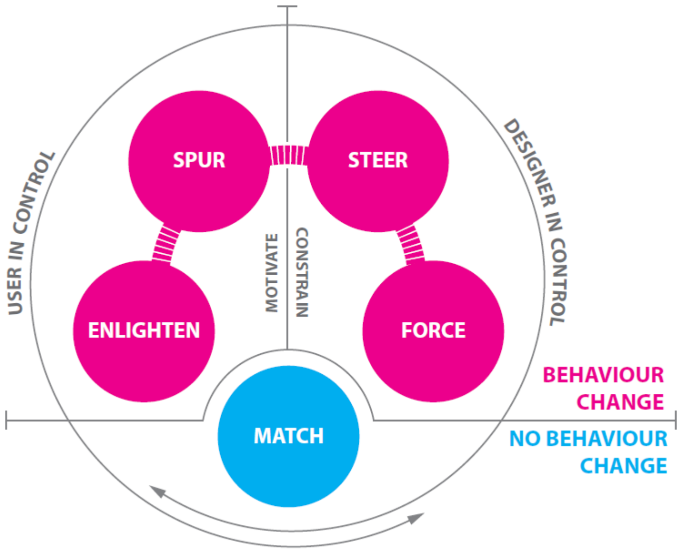


Figure 2-14. Lidman et al's (2011) Model for categorising design strategies.

Comparison of the DfSB Strategies

As pointed out by Petterson and Boks (2008) before this research even began, the field of DfSB has been growing so quickly that there is a huge range of divergent theories being employed by various different authors to explore the field better. This proliferation of investigation has led to a growing variance in the terminology used by authors in the field as each tries to better define their contribution. In a major of review of the field at the time, Boks (2012) compared the strategies and terminology of the significant contributors to the field and mapped them to a matrix (Table 2-4). Against this he compared the suitability of his and Zachrissons (2010) strategies shown in Figure 2-13 above. The descriptors provide a good match across the literature particularly when kept to a high level, i.e. Informing, Persuading, and Determining. There are some omissions from this matrix, notably the models of Wever et al (2008), and Lidman et al (2011) but aside from the important consideration of functionality matching they can be seen to fit within Lilley's (2007) and Bhamra et al's (2008) strategies respectively.

Table 2-4. Comparison of design strategies for sustainable behaviour (Boks 2012).

User in control

	Jelsma, 1997	Lilley et al., 2005	Elias et al., 2007	Bhamra et al., 2008	Lockton et al., 2010
Informing: Information, Feedback, Enabling		Eco-Feedback	Consumer education Feedback	Eco-information Eco-feedback Eco-spur	Thoughtful
Persuading: Encouraging, Guiding	Scripts	Scripts and Behaviour Steering	User Centred eco-design	Eco-choice Eco-steer	Shortcuts
Determining: Steering, Forcing, Automatic		'Intelligent' Products and Systems		Eco-technical intervention Clever design	Pinballs

Product in control

Bok's (2012) review was focused on uncovering some of the research challenges facing this burgeoning research area, one of the major issues he identified was the variance in terminology being used by different researchers. Given this, it seems wise for this research to use existing terminology where ever possible, as such the behaviour change strategy descriptors of Informing, Persuading, and Determining will be employed in this research.

2.5.2 DfSB Case studies

The growth in the research area over the last number of years has led to large number of researchers applying DfSB strategies in an effort to reduce behaviour related environmental impact. These have taken many forms, including: long and short term user studies to uncover consumer attitudes and behaviours, generation of DfSB led concept designs and prototypes, evaluation of same with users through focus groups, lab tests, and field trials. These provide a wealth of case studies to examine, both for inspiration, but also to assess any weaknesses or gaps in the field.

As part of his doctoral studies Daae (2014) compiled a comprehensive tabulated list of 28 published DfSB case studies, (at over 3 pages it is too large to include here but can be viewed in Appendix A). Each case study was detailed in terms of:

1. Product - the energy consuming system investigated.
2. Target behaviour - the aspect use to be improved.
3. Study set up – how the user information was gathered.
4. Target problem – The aspect of behaviour targeted to be changed by DfSB.
5. Proposed design solution – The design concept(s) created to target behaviour.
6. Testing set-up – The method(s), duration, and scope of the intervention testing.
7. Result – The attributable changes in behaviour of energy consumption.

While the cases studies presented are necessarily brief in description, they provide an invaluable overview of a rapidly growing area. One of the most surprising findings presented by the overview is the lack of meaningful medium-to-long term real world intervention trails with attributable mean quantitative reduction in energy consumption as shown in Table 2-5. Medium-to-long term in this case is defined as longer than 14 days.

Table 2-5. Overview of DfSB case studies evaluation.

Highest degree of testing	**Number of Case Studies**
Lab trials with prototype, varying degrees of functionality	7
Short term field trials with functional prototype	3
Medium-to-long term field trial with functional prototype	6
Medium-to-long term field trial with functional prototype with measurable net energy reduction.	1*

If the ultimate goal of Design for Sustainable Behaviour is to design products, services, and systems which result in a reduction of environmental impact in use, the lack of case studies which achieve this is remarkable. The one example which did achieve a achieve a measured reduction over a long trial period was an evaluation of a commercial Home Energy Management System (HEMS) by Van Dam et al (2010) in the Netherlands. The device was not designed in accordance with DfSB principles per se, but the authors' evaluation of the trial sits comfortably within the DfSB canon. These HEMS devices were trialled in 304 homes and recorded an average reduction in consumption of 7.8% over the first 4 months, however this did not last and there was no discernible energy reduction 11 months later.

There are many possible reasons why there are so few medium-to-long term intervention trials generating a net energy consumption reduction; developing functional prototypes is extremely time and resource consuming; building in attributable quantitative measurement into an intervention trial is not always possible, DfSB is a new field and many researchers are focusing on theory building. However it remains that it is a serious gap in the research field and one which needs to be addressed, as such it is worth considering what makes an successful medium-to-long term intervention possible.

Defining a criteria for intervention design.

As evidenced by the number of case studies reviewed, it is clear that other researchers have tried to address the lack of successful intervention trials, but have thus far been unsuccessful for a number of reasons. Given this, it is worth considering the relevant factors and defining some of the criteria that must be achieved in order for an intervention to achieve this net reduction in energy consumption in the medium-to-long term.

One of the most obvious barriers to trialling an intervention for an extended period are the technical challenges involved in creating robust functional prototypes that can last a meaningful duration. The technical capacity available will vary from project to project, depending on skills and resources available, so it is enough to say that the intervention should be technically feasible.

Similarly obvious, but equally important is that the proposed behavioural changes are possible for the user. This is not just a case of ensuring that the behaviour is physically possible to enact, but that is acceptable to the user's norms and situation. For example, you would be unlikely to convince an image conscious nurse to only bathe once a month, nor a family in Scotland to not use their central heating in winter: those behaviours are not possible for those users. Just what exact behaviours are "possible" can likely only be identified through an empathic user centred approach.

While the previous two criteria could be said to be applicable to any branch of design research, there are a couple of criteria specific to the field of DfSB. These are focused on ensuring that the proposed intervention trial delivers a verified reduction in energy consumption. Firstly, that any proposed change in behaviour must *actually* result in reduction in energy consumption, which if attributable to the intervention can be termed an *energy gain*. This criterion seeks to ensure that any alternative behaviours the users' perform due to the agency of the intervention end up consuming less energy than the original targeted behaviour. For the most part this should be relatively clear cut, the designer should have a clear understanding of the energy impact of the change being proposed and be able to show that it is less than the impact of the original behaviour. However, this is not always as straight forward as it seems; for example an intervention seeking to reduce tumble drying may be successful at getting people to stop using their dryers, but it could transpire that in order to do so they start turning on the central heating and opening their windows – behaviours with a potentially much higher impact. To safeguard against these "rebound" situations the researcher must be prepared to prototype and test early interventions early to uncover how users' react and the related energy impacts.

Lastly, in order to fully uncover how users react, and what the actual difference in energy consumption is, must be possible to measure the change. The change in both the target behaviour and related energy consumption needs to be measured using a reliable quantitative method like a data logger, smart meter, etc. To do so the intervention needs to be conceived in a way which not only measures the performed behaviour, but also the energy consumption savings *attributable* to it. This last factor is key; if a clear link cannot be drawn between the intervention's effect on behaviour and the resulting level of energy consumption then it is impossible to attribute any reduction in energy consumption to it.

In order for this to be achieved it is necessary to first establish what the baseline energy consumption and target behaviour levels are. It is then necessary to ensure that the design of the intervention establishes a clear casual effect between what it does, how the user reacts to it, and the energy consumption of the system being measured. This causality can only be established when any variable which impacts the energy consumption is measured both prior to and during the trial and is factored into the final evaluation.

An example of how difficult this can be in practice is visible in the heating intervention trial conducted by Wilson (2013) in a social housing development in Wales. The intervention aimed to provide feedback to the occupants when the window was open while the central heating was on. The intervention could measure if the window was shut while the heating was on, but due to the lack of a baseline measurement had no way of establishing whether this occurred more or less frequently than before the intervention arrived. In addition, each occupant's heating consumption was driven by a large of variables such as season: weather, occupancy level, variable heating preferences, to name a few. The net result of this "noise" was that it was impossible to attribute any quantitative change in energy consumption to the intervention after a substantial trial of 4 months.

This quantitative measurement may provide positive evidence of a behavioural change, but it may not account for secondary rebound effects nor will it cast any light on why people changed their behaviour. This information can likely only be gained by qualitative inquiry methods.

These four criteria for intervention design and trial can be summed up as follows:

1. Ensure that the proposed alternative behaviours are possible for the user.
2. Ensure that the proposed alternative behaviours provide a defined energy gain over existing behaviours.
3. The intervention proposed must be technically feasible within the scope of the study.
4. Ensure that any change in behaviour and energy consumption is measurable by both qualitative and quantitative means.

2.6 Implementing Behaviour Change

2.6.1 Selection Strategies

"One of the commonly agreed upon research challenges in design for sustainable behaviour research is to overcome the lack of understanding of when to apply what type of behaviour-changing strategies." (Boks 2012)

In his review of DfSB literature, Boks (2012) highlights the need for an understandable and reliable means of selecting an intervention strategy. As seen in the previous section the growth in the field has led to a proliferation of research outputs, each differing to varying degrees, but none offering a proven solution to this question. This section will examine the literature in this area.

The DfSB methodologies outlined previously represent a potentially powerful set of environmental behaviour change strategies, however their effect can only be realised if the various interventions approaches are correctly matched to the user's needs, knowledge and logic (Wever et al., 2008; Jelsma and Knot, 2002). This implies that a User Centred Design approach is taken to uncover users' needs and understand behaviours and the physical and societal context in which their action/choices take place (IDEO, 2009; Wilson, 2010; Wilson, 2013, Tang and Bhamra, 2008a). In order to create even more effective interventions it may be beneficial to delve deeper into the antecedents of the captured behaviours. Lindenberg and Steg (2007) state that interventions may be more effective when situational and individual determinants of behaviour as well as focal and background goal frames are taken into account. This form of holistic consideration should prevent a misinterpretation of the user's goal and motivations and prevent the assigning of an unwelcome or inappropriate intervention.

Having determined the casual factors in a given behaviour one can then employ a suitable level of DfSB strategy. Lilley states that the transition from passive to coercive intervention should be enacted in a sequential manner in response to the following variables:

- The user's level of compliance.
- The gravity of the consequences of the behaviour.
- The context in which the behaviour takes place.

(Lilley, 2009)

These concerns withstanding, Lilley (2009) maintains that the designer must still balance and ratify their design intent, the ethics of the intervention strategy and all possible foreseeable consequences of the intervention's use.

The Consumption Behaviour and Design Interventions Framework (Tang and Bhamra, 2008a) specifies the level of intervention should be matched to the established level of habit formation. While habit strength could be measured using investigative methods like the Self Report Habit Index (Verplanken and Orbell, 2003), this will would rank the habit's strength but not necessarily place it within Anderson's (1982) three-part framework. Furthermore the model may not fully allow for the fact that any new PSS based design intervention is in effect a partial change of context which could potentially re-write the original habit cues. Overall, there seems an excessive number of variables in the model for a designer to address in using it correctly. However the model is very promising in some respects; there does seems to be strong link between the level of establishment of a behaviour and need for increasing the intervention's level of agency. It is perhaps the defined linear nature of the intervention selection which is most troublesome; there are different situations when intervention approaches other than those specified might work. It is important that some degree of flexibility is given to the designer to allow for the myriad of factors inherent in each behavioural situation.

In contrast to this approach, Midden et al (2007) argue that it not the strength of the habit or behaviour which should determine the intervention strategy but rather the users willingness to delegate control to the product. This takes into account the consumer trend to hand control of strong affective and habitual behaviours over to complex automated technological systems. For example instead of taking pride in their directional abilities or traffic avoidance skills, or even just driving to regular destinations on habitual "auto-pilot", people are increasingly happy for in-car navigation systems to make the decisions for them. Midden et al. (2007) therefore advocate user trialling and prototyping of different levels of interventions and functionalities to determine the optimum solution. However, attention is drawn to the need for user trust in any technological system. As shown previously, human behaviour is complex, emotional and often irrational and should the technology fail to perform as desired it risks being rejected by the user (Midden et al., 2007). This method has a significant issue in practice, that the designs must be first developed before they can be rejected or accepted by the user. Furthermore there is no guarantee that the intervention approach which the user deems suitable is actually one which would reduce energy consumption.

Renström et al (2012) have sought to illuminate the different paths which a consumer can follow to reduce the environmental impact associated with use of a product. Their Five Pathways of Sustainable Behaviour, Figure 2-15, rightly broaden the focus of DfSB to consider aspects outside the primary product/user interaction and consider the user product engagement in a holistic sense. The five pathways can be summarised as follows:

1. **Changed use:** By themselves, people change how or when they use a product, or just reduce how much they use a product to reduce environmental impact.
2. **Mediated use:** People can use a secondary artefact to mediate the use of the first, either by providing feedback or guidance on how to reduce environmental impact through use or by reducing use of the artefact, e.g. energy monitor.
3. **Regulated artefact**: People can acquire a secondary artefact which technically reduces the environmental impact of the primary artefact when used, eg, home insulation.
4. **Maintenance and repair:** Correct maintenance and repair can lead to substantial efficacy gains, people could be prompted through design to do so.
5. **Choice of artefact:** People can be guided to choose an environmentally superior artefact at the time of acquisition.

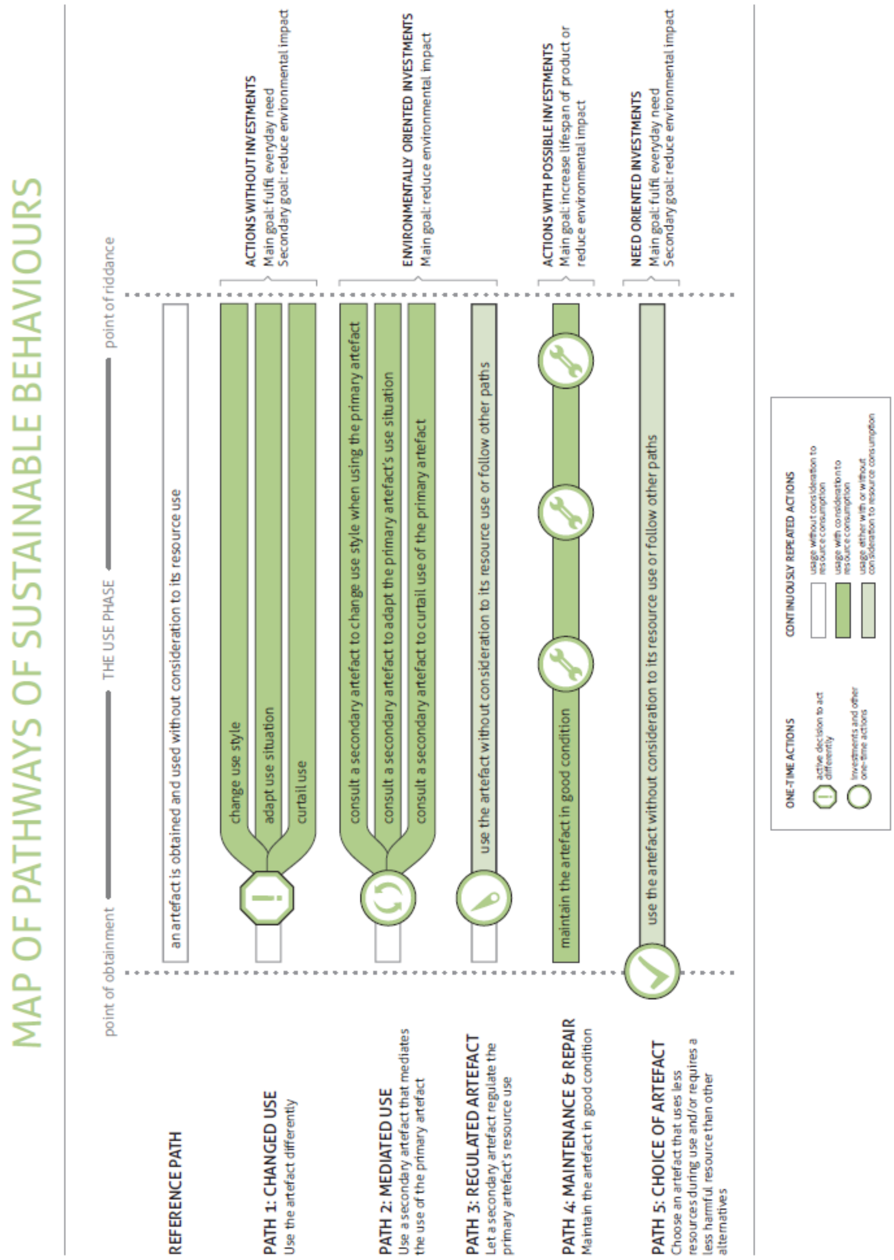


Figure 2-15. Map of Five Pathways to Sustainable Behaviour (Renström et al. 2012).

Though ostensibly referring to user behaviour, the Five Pathways can also be viewed as an intervention selection strategy for designers trying to effect a change in user behaviour. The model is useful at forcing the designer to consider different ways of effecting change outside of just a product redesign. However the model does not provide much guidance on when to choose each pathway, nor does it attempt to provide guidance on which DfSB strategy to apply in a given situation.

2.6.2 Selection Models

Fogg's Behaviour Model (2009a) is drawn from his studies of computers as persuasive technology (captology) (2003; 2006; 2009a; 2009b) and focuses on the required facilitative capacity of the intervention to bridge the gap between the user's motivation to perform a task and their (perceived) ability to do it (Figure 2-16). In short, for an intervention to successfully trigger a behaviour (new or existing) to occur, the difficulty of the behaviour must be in proportion to the user's motivation to do so. This means that to trigger a new environmentally beneficial behaviour an intervention must increase the user's motivation through persuasive means and/or make the behaviour easier to do through technological innovation. As a selection tool for DfSB interventions the model provides guidance on the assignation of interventions from user agentive to technologically agentive, with user agentive interventions generally aimed at increasing motivation and technological agentive ones increasing ability.

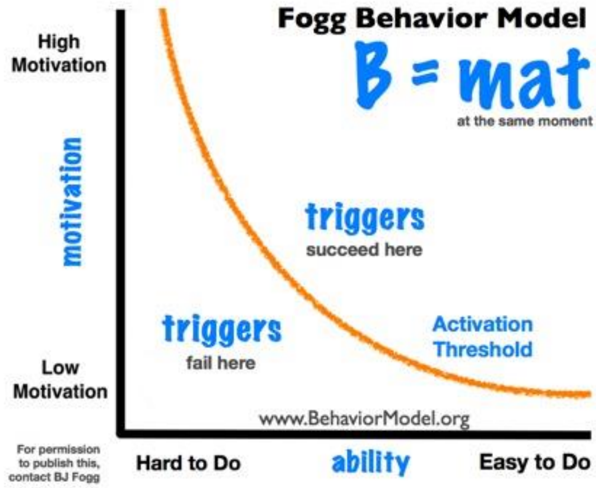


Figure 2-16. Fogg's Behaviour Model (Fogg, 2009a)

While Fogg does not consider coercive technologies ethically suitable, it is possible to incorporate them into the model as they, in effect, make the (designer's) desired behaviour "easier" to do by forcing it's occurrence. Zachrisson and Boks' (2010) model of user attitude and division of control (Figure 2-17) does include coercion (forcing) as potential intervention strategy and positions it's effect similarly. The model originates from a DfSB background but can be read in parallel to Fogg's Behaviour Model if motivation is correlated to user attitude, and ability is correlated to the product's automaticity in completing the task.

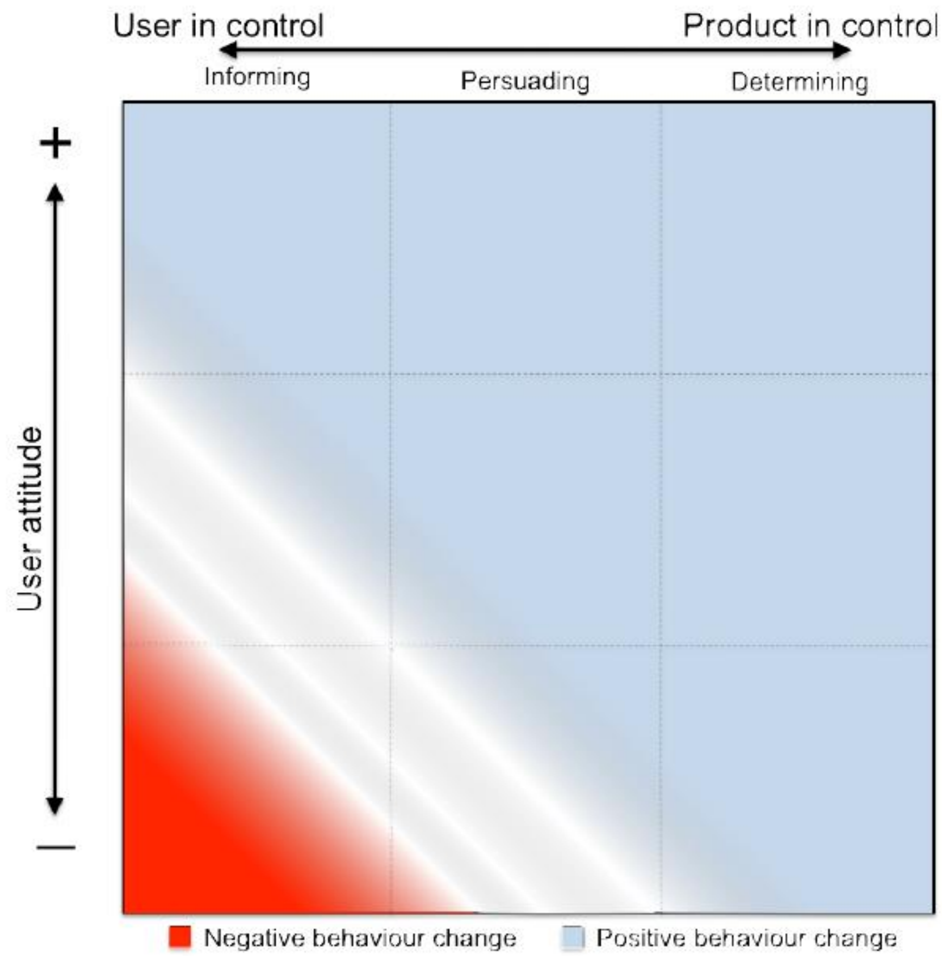


Figure 2-17. Relation of user attitude and division of control (Zachrisson and Boks, 2010).

Both Fogg's (2009a) and Zachrisson's (2010) selection models target user attitudes as the key variable. This is an interesting angle but one which does not fully account for the role of habitual or semi-automatic behaviours, or indeed of the numerous situational factors that could influence a given behaviour. In addition it does fully allow for the fact that if a technology doesn't work as desired the user may get rid of it, or choose not to use it. In this sense Fogg's (2009a) model is more accurate as it acknowledges the limits of this strategy in extreme cases.

The Design guide for DfSB

Following on from the model above, Zachrisson et al (2011) recognised these weaknesses and drew on behavioural psychology to better account for the full range of factors that might influence intervention selection. Based around the Comprehensive Action Determination Model (Klöckner & Blöbaum 2010) (CADM) they produced a Design Guide for DfSB, Figure 2-18, which sought to address each of the variables the CADM highlighted as being of significance (Zachrisson & Boks 2012).

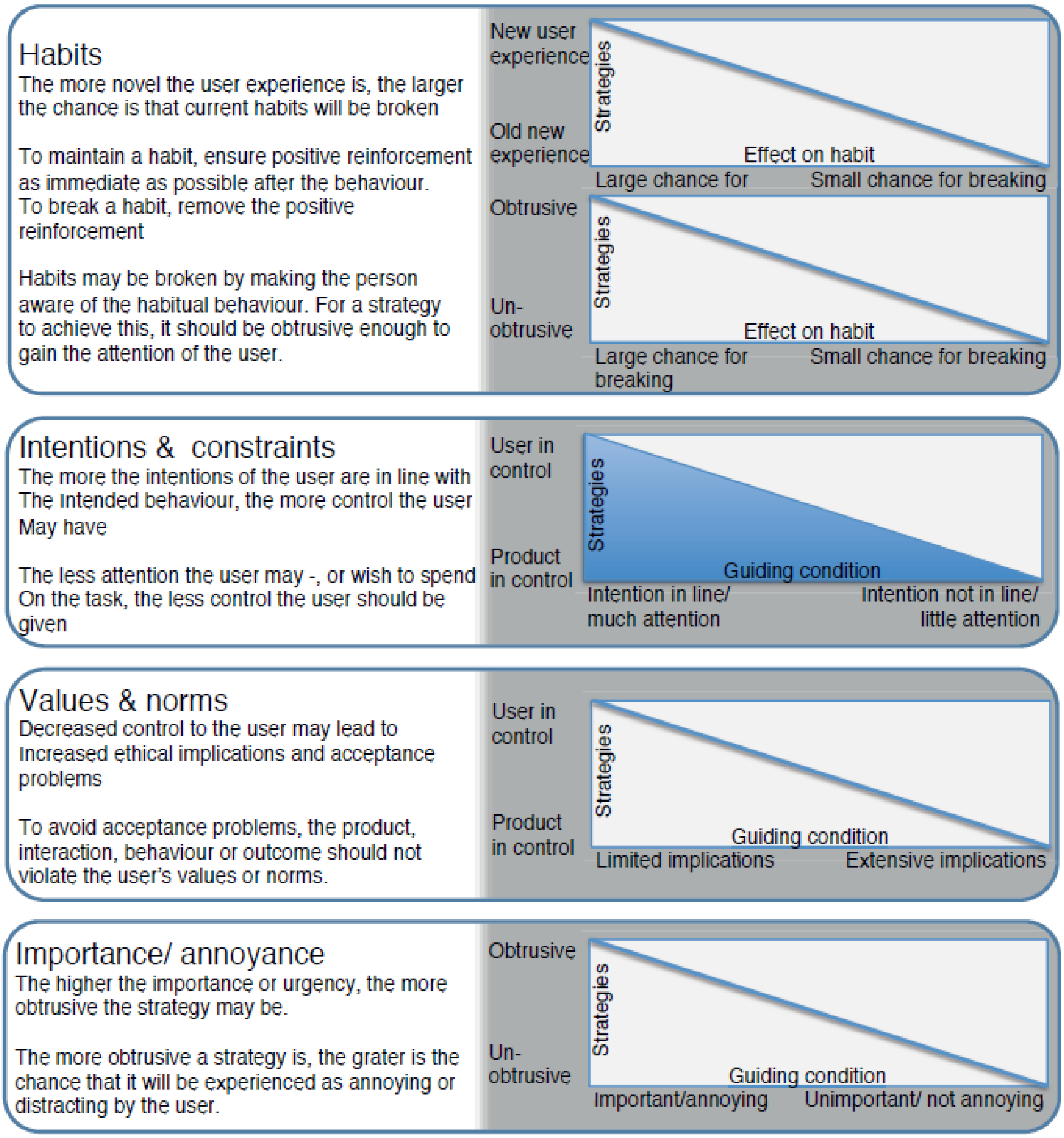


Figure 2-18. Design Guide for DfSB (Zachrisson et al. 2011).

The four main aspects of behaviour addressed are; Habit, Intentions & Constraints, Values and Norms, and Importance/Annoyance. These are presented in separate panels, with a corresponding graphical representation of the relationship between the strength of the intervention strategy and the scope of the behavioural aspect. For Intentions & Constraints, and Values and Norms the strategies present are the User/Product Agency Axis. For the categories of Importance/annoyance and Habits the strategy relates to the level of Obtrusiveness the design exhibits. Obtrusiveness is defined as *"how much attention the product demands from the user"* (Daae & Boks 2014) and refers to how much an intervention inserts itself into the behavioural sphere. This is a very interesting concept and one which allies well with findings on the level of contextual change needed to disrupt habitual behaviour. The other strategy employed for Habit change is the novelty of the experience, this again refers to the need for habits to be broken through a significant change in how the behaviour is performed.

While Zachrisson et al's (2011) guide brings some very interesting strategies targeting different aspects of behaviours to light, ultimately it does not work as it's authors intended. By directly drawing out individual aspects of behaviour from the CADM models and applying different strategies to each, the model lacks a holistic sense of the actual behaviour as performed. This leads to situations where a designer's interpretation of the appropriate design strategies for each of the individual behavioural antecedents can be directly in conflict with each other. This is compounded when the designer analyses the behaviour of multiple individuals with conflicting behavioural antecedents. This weakness was noted by the guide's authors who suggested that in such cases the designer would have to decide which aspects are the most important to include in the design.

Perhaps even more important than any theoretical inconsistencies in what is a very accomplished piece of research, are the issues the guide's authors encountered when trying to actually employ the guide in the design process. Taking a project investigating oral health care in the Netherlands as a case study, the authors tried to apply the guide to a large body of designerly user research (interviews, video observation, cultural probes, etc). They encountered difficulty in matching the observations to the categories presented by the CADM and conceded that it might prove overly complex to be useful to designers:

The behavioural factors identified by social psychology, as for instance presented in the CADM, can be difficult to grasp for designers within the limited time they normally have at their disposal. (Zachrisson et al. 2011)

A very interesting finding from the case study was the detrimental effect on design that the high level of complexity of some behaviour models have. This provides some support for using Goal Framing Theory (Lindenberg & Steg 2007) to guide design rather than a more complex construct like the ToIP (Triandis 1977) or CADM (Klöckner & Blöbaum 2010). Goal framing theory positions behaviour in readily understood terms and focuses on why people are doing what they are doing, and thus provides ready insight into one of the main issues uncovered by Zachrisson et al's (2011) guide.

"Rather than trying to distinguish between attitude, beliefs and intentions, it might be sufficient to figure out the intentional factors, or "what the user wants"." (Zachrisson et al. 2011)

2.6.3 Tools and Architectures

When a target behaviour and relevant intervention strategy(s) have been selected there are a number of tools and architectures which can be used to help realise the design. One of the most comprehensive collections of these is Lockton's Design with Intent (DwI) Toolkit (2010) , which offers a 101 behaviour affecting gambits categorised into eight categories or lenses. The DwI Toolkit (Figure 2-19) is designed to provide quick access to a broad range of proven solutions which the designer can either apply directly to the chosen behaviour, or draw analogies from to create new approaches specific to their own brief (Lockton et al., 2009).

Figure 2-19. Lockton's DwI toolkit (2010).

The eight categories presented look at different aspects of design and emotional and cognitive persuasion, a brief description of each follows:

- Architectural Lens – examines using the structure of systems to influence behaviour.
- Error proofing Lens –treats deviations from the target behaviour as errors and seeks to either make them harder for users to make or impossible.
- Interaction Lens - looks at the key principles of interaction design with a focus usability and persuasive mechanisms.
- Ludic Lens – takes elements of game design which attract and keep users by leveraging the characteristics of play and competition.
- The Perceptual Lens - combines product semantics, semiotics, ecological psychology and Gestalt psychology to examine how users perceive patterns and meanings as they interact with the systems around them.
- The Cognitive Lens - draws on research in behavioural economics and cognitive psychology looking at how people make decisions and the effect of their heuristics and biases.
- The Machiavellian Lens – looks and some of the perhaps more unethical mechanisms for influencing people in use today.
- The Security Lens – examines some of the methods used to deter users from performing the undesired behaviour.

(Lockton, 2010)

The DwI toolkit offers some very powerful mechanisms to effect behaviour change and compliance, however it must be noted that it does not, in itself, provide any guidance as to when these should be used nor on the ethical acceptably of the mechanisms (Wilson, 2010).

2.6.4 Ethical Considerations

As previously stated, DfSB methodologies change the role of the designer from a facilitator to a sustainable activist (Lockton et al., 2009) with the express intent of changing user behaviour (Fogg, 2003). This raises a number of issues about ethics, including whether DfSB by its very nature can be deemed to be unethical (Fogg, 2003; Lilley, 2007). Fogg (2003) maintains that persuasion itself is neither ethical nor unethical, rather that determination can only made by looking at how it used and to what end. In a comprehensive review of the literature regarding the ethical considerations of DfSB and Persuasive Technology, Wilson (2010) identifies four major domains of concern to designers. These are the domains of; individual freedom, designers intent, methods of persuasion, and responsibility for outcomes.

Individual Freedom

Berdichevsky and Neuenschwander (1999) were one of the first to formalise ethical criteria for the creation and application of persuasive design with their eight ethical principles (see Table 2-6). The principles are broad ranging, and while open to subjective interpretation, provide useful guidance on most of the relevant areas. They seek to enshrine the rights of the individual and to ensure that the agency of the technology is not used for subversive means. However, as the principles were expressly created for the realm of HCI they do not fully address the broader range of approaches and interventions designers could employ (Lilley and Lofthouse, 2008) and the potential for unintended outcomes resulting from use (Pettersen and Boks, 2008).

Table 2-6. Ethical principles of persuasive technology (Berdichevsky and Neuenschwander, 1999).

Ethical Principles of Persuasive Technology
I. The intended outcome of any persuasive technology should never be one that would be deemed unethical if the persuasion were undertaken without the technology or if the outcome occurred independently of persuasion.
II. The motivations behind the creation of a persuasive technology should never be such that they would be deemed unethical if they led to a more traditional persuasion.
III. The creators of a persuasive technology must consider, contend with, and assume responsibility for all reasonably predicted outcomes of its use.
IV. The creators of a persuasive technology must ensure that it regards the privacy of users with at least as much respect as they regard their own privacy.
V. Persuasive technologies relaying personal information about a user to a third party must be closely scrutinized for privacy concerns
VI. The creators of a persuasive technology should disclose their motivations, methods, and intended outcomes, except when such disclosure would significantly undermine an otherwise ethical goal.
VII. Persuasive technologies must not misinform in order to achieve their persuasive end.
VIII. **The Golden Rule of Persuasion.** The creators of a persuasive technology should never seek to persuade a person or persons of something they themselves would not consent to be persuaded to do.

Designer's Intent

It has been suggested that one means of determining the ethicality of a persuasive of DfSB intervention is to examine the intention of the designer creating the intervention (Fogg, 2003; Lilley, 2009). Doing so may provide some clarity if the final design solution perhaps utilises some persuasive mechanisms which, if considered on their own, might not be deemed one hundred percent ethical. However, here again the issue of subjectivity on the part of designer or reviewer is raised, as *"persuasive intent arises from a social context"* (Davis, 2009) one which may not be shared by all intended users. Davis (2009) advocates the use of multi-stakeholder participatory design as a means of determining if the design intent is deemed ethical by the intended users. The optimum nature and extent of this type revelation is still uncertain as researchers such as Dolan et al. (2010) argue that a key tenet of successful design for behaviour change is that the intend targets are not aware of it as that.

Methods of Persuasion

Fogg (2003) states that there are some methods of persuasion which are inherently unethical including the use of deception and coercion. In captology, coercion can be defined as enforced change to the benefit of the product not the user (Fogg, 2003). However in DfSB theory, coercion would be used to an environmentally beneficial end and is more aligned with a product's technological agency and not in itself unethical, rather it is subject to individual perceptions of ethicacy (Lilley, 2007). Operant condition and surveillance are methods whose ethicacy is subject to the manner in which they are implemented i.e. if they are overt and harmless to the user they can ethically acceptable tools. Similarly the use of emotion to persuade is dependent on the outcome sought from the user, as well as factors such as the age and/or mental capacity of the user (Fogg, 2003).

Responsibility for Outcomes

Because DfSB and persuasive technology interventions are trying to effect change through people their performance cannot be measured purely by functionality, but rather by how people actually use them (or don't). This concerns the analysis of the outcomes of use, something that can only be predicted in the design stage as different users will utilise a given design in different unforeseen ways (Pettersen and Boks, 2008). These unforeseen uses can create issues related to the safety of the user or increased energy use (Pettersen and Boks, 2008), or may just be a reflection of an unacknowledged user need (Rodriguez and Boks, 2005). Fogg (2003) maintains that in order for the designer to be considered ethical in their decision making, they must consider not only the ethicacy of their intended outcome but also that of any potential unintended outcomes. Thus, by systematically considering potential "misuse" scenarios and taking the responsibility to rectify them in the design stage the designer can be said to be acting ethically. This evaluation of intended and unintended outcomes is illustrated in Figure 2-20.

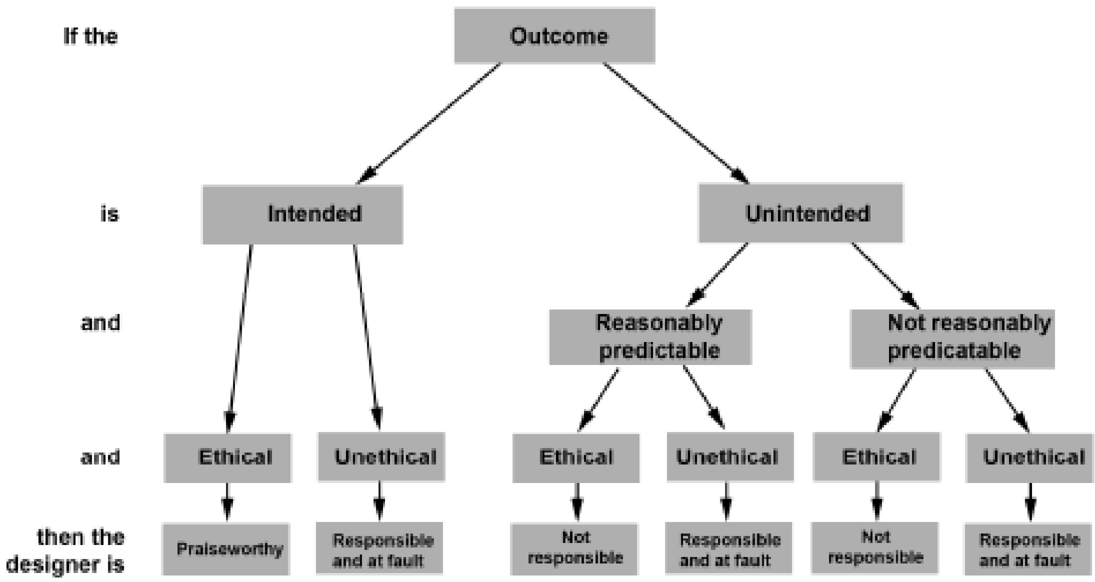


Figure 2-20. Evaluation based on intended and unintended outcomes (Fogg, 2003).

2.7 Conceptual Model

The findings of the literature review have been drawn together in a conceptual model (Figure 2.21) of the relationship between the user, their context, and behaviour. Models are an abstraction or simplification of reality, and can help define questions and concepts more precisely. They can assist in generating and testing hypotheses and help generate predictions (Heemskerk et al., 2003). Furthermore the process of building a model can be as enlightening as the model itself as it reveals what is known and unknown about the connections and causalities of the system (Jackson et al., 2000), as was certainly the case in this instance. The model is conceptual in nature rather than empirical, as conceptual models require less prior modelling experience and are vital for defining research questions (Heemskerk et al., 2003)

The model takes as a central concept; that the user operates in given physical and societal context and that their behaviour as such is shaped by the constraints and affordances thereof. Within their context each user is considered to have their own practical knowledge, attitudes, and beliefs, factors which shape their worldview and are unique to the individual. When a user makes a decision to act (or not) it is driven by a combination of active goal frames; hedonic - to feel better now, gain – to guard or improve one's resources, normative – to act appropriately (Lindenberg and Steg, 2007). In each instance one goal frame will be dominant to the others and will direct the behaviour. However while the behaviour is in the early declarative phase (Anderson, 1982), the active goal frame is not fixed and can change from instance to instance, e.g. while fear of a fine might initially motivate someone to separate their recycling (the gain goal frame dominant), if they find it wearisome they may decide not to continue with the effort (hedonic goal frame dominant).

If the behaviour is regularly repeated and the context remains the same, then it will become more automatic and require less and less cognitive deliberation (Verplanken and Aarts, 1999). The behaviour now becomes habitual and is initialled by contextual cues and is often performed outside of the user's conscious awareness. In this form a habit can perpetuate and strengthen until there is a change in the context or in the user's knowledge, attitudes and beliefs.

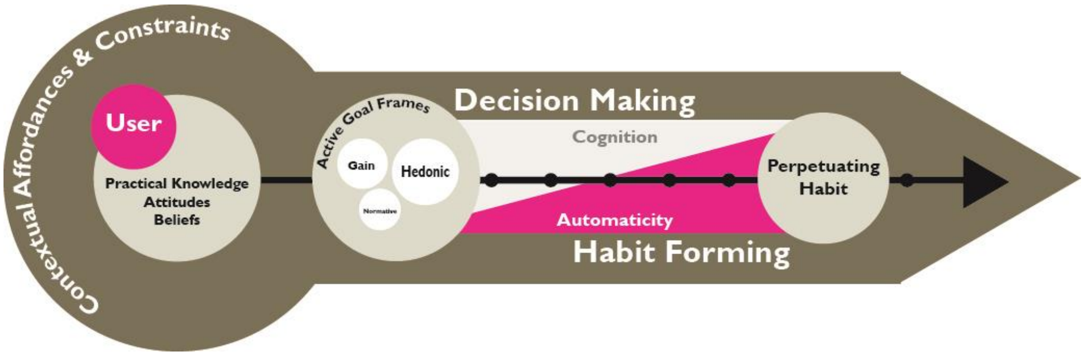


Figure 2-1. Behaviour in Context model.

The author contends that designed interventions, when combined with an appropriate DfSB strategies (e.g. Lilley, 2009; Wever et al., 2008), can provide the vehicle for such a change in context or in the user's knowledge, attitudes and beliefs. They reshape the user's physical context by their presence and the way they insert themselves into the user's lives. It is even possible that digital interventions, by providing automatic sensing and connectivity and remote control, enable users to act on a new virtual stage unencumbered by existing contextual cues (Microsoft, 2008). By thus changing the context, DfSB interventions can break the hold of the user's existing context on their behaviour and bring a user's behaviour back to the declarative stage (Zachrisson and Boks, 2010). At this point the full range of DfSB strategies can be employed to give the user new knowledge, and to shift their attitudes and beliefs towards more environmentally beneficial ones. If successful, when the user embarks upon new behaviour, different factors will affect the active goal frames, leading to a more sustainable choice, as illustrated in Figure 2.23. While it might be expected that environmentally beneficial behaviour would be driven by revised active normative goal frames (Lindenberg and Steg, 2007), in actuality it would depend on the interplay of the designed affordances and constraints of the system and the nature of the user's new knowledge, attitudes and beliefs.

Key in this process is the selection of a combination of an appropriate DfSB strategy and the requisite contextual change. To this end the user's active goal frames must be understood and the nature and degree of habit formation ascertained. The goal frames can be revealed through targeted interviews and participatory design activities incorporated into the HCD process. Obviously, the selection of the DfSB strategies and the level of contextual change enabled are subject to the same ethical concerns outlined in previous sections, and should also be addressed through a participatory design approach (Davis, 2009).

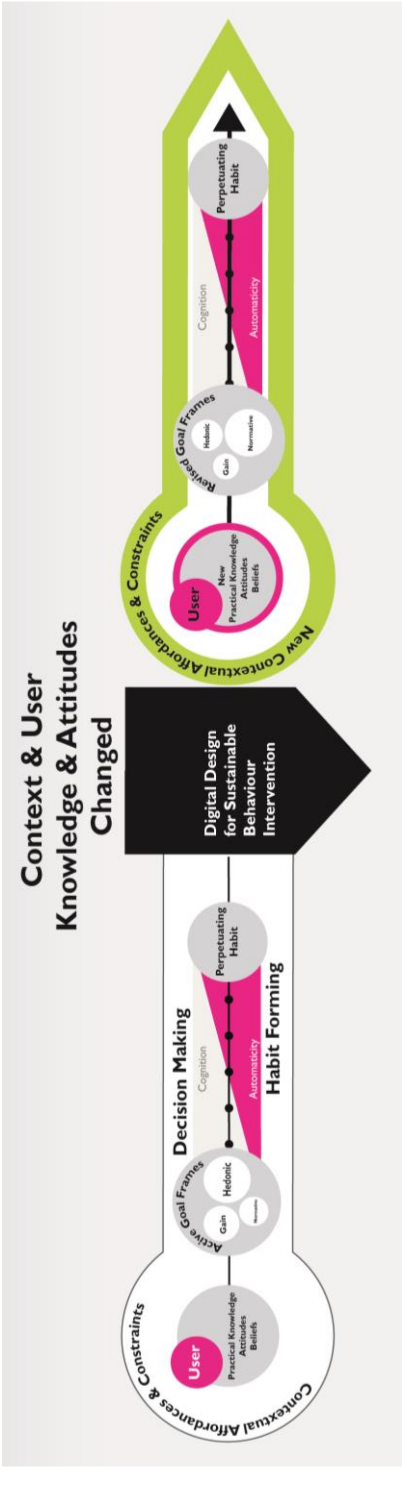


Figure 2-21. Conceptual model of Design for Behaviour Change

2.8 Conclusions

2.8.1 Behavioural Models and DfSB

Behavioural models have been shown to be a useful tool in conceptualising the decision making process, however the majority of them are too complex and detailed to be truly useful to the design process. An exception in the literature is Goal Framing theory, which posits that behaviour is driven by a combination of three readily understandable goals; Gain, Hedonic, and Normative. While it does not attempt to capture the origins or nature of the underlying knowledge, attitudes and beliefs of the individual, it may isolate potentially powerful active user goals frames which could either direct further research or even be harnessed or subverted by DfSB interventions. As much design work is already oriented to meeting user goals it should allow for easy translation across disciplines. However its relevance is still untested in this field and will require further application to ascertain its validity to the DfSB process.

While situational context has been shown to a significant effect on behaviour, particularly in the role of norms and as a cue for automatic and habitual behaviour, it has not been researched significantly in the realm environmental psychology. In particular, the importance of the micro context (i.e. the layout of the home and the affordances and constraints of the appliances therein) has not been accorded the study needed to determine its role in our energy related behaviours. This lack of study has been highlighted by some researchers (e.g. Midden et al., 2007) and is surprising as it would seem little could be more relevant to environmental psychology than the effect of the actual environment of use. Situational context is considered a key concern in the realm of HCI and UX design, both new disciplines which have learnt from experience that novel technologies and interactions can only succeed when it has been factored into the design process. In addition, it is necessary to study the nature of the impact DfSB interventions themselves have on the situational context; their role as context shapers and the resulting impact on context dependent behaviour. By doing so, a greater understanding of the interventions own agency may be revealed, which in turn may allow for this effect to be harnessed in future DfSB work.

Similarly, habits themselves have been shown to be a major constituent of our behaviour, yet the nature and extent of the role they play in domestic energy use is unclear, and needs more study. The power of habits is unquestioned, but as a means of potentially creating and perpetuating “good” behaviours, they have not been sufficiently targeted by DfSB interventions. This is, in part, due to a lack of literature on how habits can be created and the impact of design interventions in contextual change. It remains to be seen whether one can make or break habits through design intervention alone, and what the nature of such interventions should be.

The conceptual model presented in this chapter provides a novel means of displaying the constituent factors that shape user behaviour. It allows the graphic representation of dominant goal frames, while keeping secondary goal frames visible. It places behaviour in a given context, rather than making context just another variable. Importantly, it allows categorisation of the level of automaticity expressed in the behaviour, allowing designers to understand, not just the constituent factors driving the behaviour, but also the nature of the behaviour.

Crucially, the conceptual model also illustrates the effect that design intervention has on the factors which shape behaviour. Interventions have potential not just to change the physical context, but can also link us to a different social context. Design can change our practical knowledge, reframe out attitudes and even change our beliefs. In so doing so it can break existing habits and make new ones. For example, consider the effect the introduction of smartphones has had on after hours working and inter colleague communication.

2.8.2 User Centred Design

The literature shows a strong need for an iterative User or Human Centred Design (HCD) process which incorporates or acknowledges elements of context mapping and participatory design for a number of compelling reasons;

- to ensure functionality matching with user requirements.
- to uncover and address user’s latent desires and tacit knowledge.
- to determine the users willingness to delegate control to the technology.

- to determine the effects of ergonomic and aesthetic elements of design interventions on user compliance.
- to ensure ethical suitability.
- to ensure bug fixing, technical suitability etc.
- to develop compelling user experience.

This approach is explicitly advocated in DfSB, HCI, and Ux design literature but is also covers many of the concerns implicit in environmental psychology and behaviour change literature. As such it is clear that this process should be followed in the course of this research.

2.8.3 DfSB Selection Tool

There is a well-defined need for a DfSB intervention selection tool which must be usable by designers and reliable. A DfSB selection tool should provide a simple holistic lens to view a target behaviour. The number of variables both in terms of behavioural antecedents and variations of intervention strategy cannot be processed in a systematic linear way. The more comprehensive a model might be, perhaps the less likely its success as a tool for design. Design is not a purely linear, sequential activity and cannot be forced through a rigid process, however theoretically accurate, which stifles the creativity of the designer.

Rather it may be more beneficial for such design tool to just help the designer see the problem more clearly. That is, to bring a manageable number of important factors to the designer's attention, in a way which allows them to see the inter-relationality of the problem, but which gives enough space for the designer to arrive at their own solution thorough the designerly processes of synthesis, evaluation, and iteration. The user centred design process provides a means for the designer to formulate incomplete design proposals which can be evolved into more successful and complete concepts through testing and iteration.

2.8.4 Intervention Trial

As shown by the literature many energy consuming behaviours are heavily influenced by context and routine. Following this it stands to reason that any DfSB intervention produced can only be fully evaluated if tested in its intended context of use and for an extended period. Analysis of DfSB case studies has shown that there is a significant gap in the research relating to the medium-to-long term trial of interventions which demonstrate a measurable reduction in energy consumption. Though the development and trialling of functional prototypes is known to be extremely resource and time consuming it is considered a crucial element of any further research.

In order to ensure that any intervention developed can achieve this, a list of 4 criteria for DfSB intervention have been drawn up. They are:

5. Ensure that the proposed alternative behaviours are possible for the user.
6. Ensure that the proposed alternative behaviours provide a defined energy gain over existing behaviours.
7. The intervention proposed must be technically feasible within the scope of the study.
8. Ensure that any change in behaviour and energy consumption is measurable by both qualitative and quantitative means.

As show in Figure 2-23, all four of these criteria must be met in order for an intervention to prove its success.

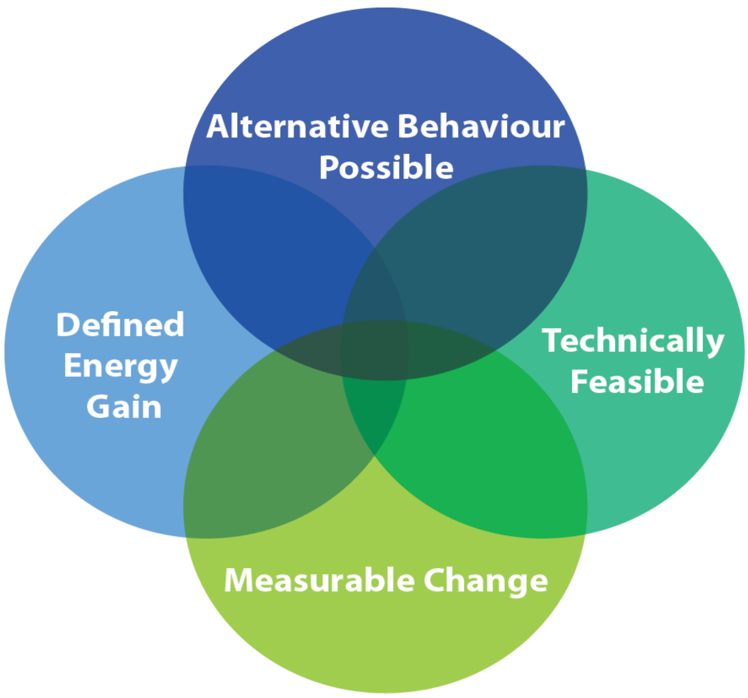


Figure 2-22. The 4 Criteria for DfSB intervention design

3. Research Methodology

3.1 Introduction

This chapter discusses the research framework employed to undertake a flexible human-centred design research investigation. It provides an over-view of the methods used for data collection and analysis in the different phases of the research. It also discusses the research strategy selected and issues related to validity and ethics which shaped the research.

3.2 Research Purpose

As identified by the literature (Lilley 2007, Wever et al. 2008; Tang and Bhamra 2008a) a user or human centred design (HCD) approach to Design for Sustainable Behaviour is necessary to map the variable contexts and understand different user's motivations and capabilities. Such a methodology can be termed constructivist as it implies the observed reality is "constructed" by the interaction of both the researcher and the research participants (Robson, 2011, p24). It is primarily exploratory in purpose as it seeks to investigate emergent phenomena (ibid) and seek new insights. As Creswell (2003, p.9) says *"Rather than starting with a theory (as in postpostivism), inquirers generate or inductively develop a theory or pattern of meaning*." This form of exploratory research is appropriate as the field of DfSB itself is relatively new.

3.3 Research Strategy

This research is driven by qualitative research methods, which are naturalistic in style and conducted in the actual context of use and seeking *"illumination, understanding, and extrapolation to similar situations"* (Golafshani, 2003). Robson (2011, p131) advocates the use of what he terms a “flexible” research design over an exclusively qualitative approach as this allows for the use of some quantitative methods within the study. This is important for two main reasons; firstly it allows for the research design to adapt to the emergent findings; and secondly quantitative methods may provide numerical validation of the qualitative findings.

There are several strategies in existence to help realise this type of flexible exploratory research approach, Robson (2011) provides an overview of three of the most commonly used which is summarised in Table 3-1.

Table 3-1. Research Strategies (Robson 2011).

Three approaches to Flexible Design Research		
Case Study	Ethnographic Studies	Grounded Theory Studies
Focused on the study of a single case (or small number of related cases) taking its context into account. Generally involves multiple methods of data collection to build a detailed picture of the selected case – be it an individual, a group, a setting, or otherwise.	Aimed towards the description and interpretation of the culture and social structure of a social group. Requires extended periods of participant observation through immersion in the culture but can also be accompanied with other methods.	Focused on the development of a theory of the particular social situation forming the basis of the study. Particularly suitable to investigating areas about which there is a lack of research or theory. Necessitates rigorous application of analytical and theory building procedures.

Given the large body of existing literature related to the subject and the development of an initial conceptual model (see section 2.7), a case study strategy was decided to be the best approach for this research. Robert Yin (2009) defines case study as *"a strategy for doing research which involves an empirical investigation of a particular contemporary phenomenon within its real life context using multiple sources of evidence"*. In this research the particular contemporary phenomenon is the contextually mediated domestic energy consumption of 20 families in the East Midlands of England. This necessitates that the research be performed in the context, i.e. in the family homes, and that it employs multiple methods of evidence or data collection (Robson, 2011). The importance of the context in defining the case study is such that Miles and Huberman (1994) suggest that in some instances the term "site study" might be preferable. In this study, where the phenomenology of people/context interaction is a core concern, this could certainly be true, however, for the sake of clarity and convention the term "case study" is used throughout.

This case study is comprised of five main phases of research and design activity, each of which informed and shaped the subsequent ones;

Phase 1: Review of the Research Field (Chapter 2).

Phase 2: User Study, (Chapter 4).

Phase 3: Design Intervention Development (Chapter 6).

Phase 4: Design Intervention Evaluation (Chapter 7).

Phase 5: Validation of BISA as a Tool to Guide Design (Chapter 8).

3.4 Validity and Credibility of Research

Due to its responsive and naturalistic approach, qualitative research can never be experimentally reliable in the sense of quantitative study (Golafshani, 2003). Instead, credibility can be sought in qualitative research (Creswell, 2007; Robson, 2011) to provide a level of validity (Robson, 2011). This research study incorporates a selection of credibility measures to ensure its validity.

Triangulation involves the use of multiple sources to enhance the rigor of the research (Robson, 2011) and was included in the following forms; Data triangulation – the use of more than one method of data collection, and Methodological Triangulation – qualitative and quantitative measures were combined in the study.

An audit trail was kept of all research activities including audio recordings and written transcripts of interviews, photographic and video materials, and quantitative consumption data where applicable as well as details of data analysis activities. Prolonged engagement with the participants sought to overcome any initial reactivity or bias and increased the chances of building trust, while allowing for the emergence of new research directions.

3.5 Scope of Research

3.5.1 Collaborative Research Activities

The research in this study has been undertaken as one part of a three strand multidisciplinary investigation within Loughborough University. Researchers from the School of Civil and Building Engineering, School of Electronic, Electrical Engineering and Systems Engineering, and Department of Computer Science gathered highly granulated energy use data from participating homes, while investigators from the Department of Social Sciences undertook ethnographic research concurrently with the participating households. While the methods and findings of their research informed and shaped this study and the subsequent design process, it will not be discussed here except to define the boundaries of this research. An overview of the different disciples and activities can be seen in Figure 3-1.

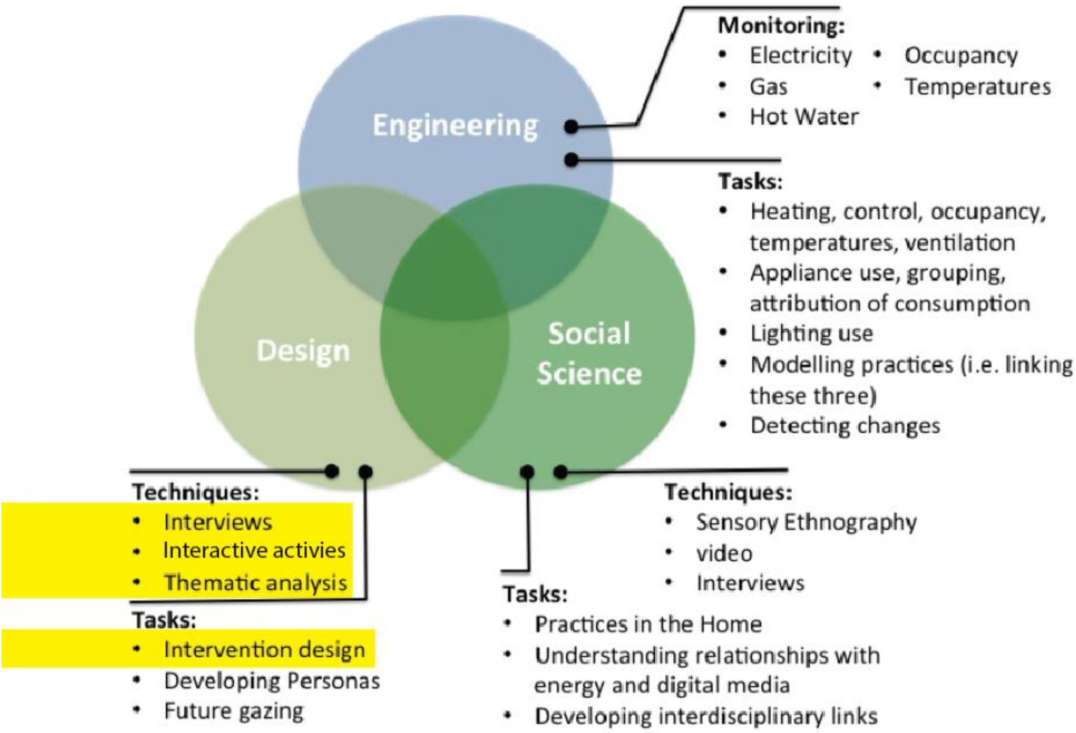


Figure 3-1. LEEDR research disciples, tasks, and techniques, with this reseach highlighted. (amended from Buswell et al. 2015).

The LEEDR project ran from October 2010 for four years in total, a period of around 2.5-3 years was spent actively engaging in research activities and energy monitoring with the participating households.

As this research took place as part of the wider LEEDR interdisciplinary project, there was a high degree of collaboration in the undertaking of the following research activities. In Phase 2, the generation of the research materials, and the undertaking of the 20 family interview sessions was shared with Dr Carolina Escobar, from Loughborough Design School, Loughborough University. This reflects the wider research focus of the design strand of LEEDR Project than those of this author's research presented here. The analysis of the collected materials discussed in this thesis was undertaken solely by this author.

As a further strand of the interdisciplinary work, it was usual for this researcher to be accompanied by a colleague from Department of Social Sciences, either Dr Kerstin Leder-Mackley or Dr Roxanna Morosanu, on all research visits to participants' homes during Phase 2 and 4. These colleagues were present to observe the interaction between the design researchers and the participants for their own investigations, and did not take an active part in the design or implementation of the studies described here.

3.5.2 Sampling Strategy

Sampling Strategy for Phase 2 and 4

The recruitment of the participants of this research was driven by the selection process of the LEEDR project as a whole. All participants were signed up to a 3 year energy monitoring project involving energy and water consumption monitoring, ethnographic research and design investigation. The participants were recruited from within a 15 kilometre radius of Loughborough University, in the East Midlands of the UK.

The participants were self-selected, with a recruitment drive though posters, and local media. In an effort to avoid an overt bias to recruiting those with strong pro-environmental views, the recruitment materials were designed to recruit people who would self-identify with a range of project themes, see Figure 3-2 below.

Figure 3-2. Recruitment posters targeting different sample types.

It follows that the project employed a purposive sampling strategy (Robson, 2011). The criteria for selection amongst those who contacted the LEEDR projects was described as follows:

- *similar building type, size, location (to help manage the engagement);*
- *occupants ages, type of occupants (not too broad, some similarities in the group);*
- *energy metering arrangements and systems (technical feasibility for monitoring);*
- *we wanted the householders to represent a range of attitudes towards energy saving and environment issues;*
- *we needed people who were willing to spend time engaging with us.*

(Buswell et al. 2015)

Participants in Phase 2: User Study

Out of the 60 families who contacted the project, 20 were selected to continue with the research, in total they came to 88 people as detailed in Table 3-2. Prior to beginning all householders were provided with an information booklet designed to explain all the planned research activities, see Appendix B. All of these households took part in Phase 2 of this research.

Table 3-2. Breakdown of LEEDR participants at beginning of project.

Code	No. of adults	Ages of children				House Type	No. Beds
H01	2	19	17	10	-	Detached	4
H05	2	19	12	-	-	Semi	3
H08	2	14	11	-	-	Detached	6
H09	2	10	7	-	-	Detached	4
H10	2	4	2	-	-	Detached	4
H11	2	10	4	-	-	Semi	3
H18	2	18mths	18mths			Detached	4
H23	2	3.5	14mths			Semi	3
H28	2	16	14			Semi	3
H30	1	10				Detached	3
H33	2	7	5			Semi	4
H37	2	9	6			Detached	4
H38	2	18mths				Semi	3
H39	2	11	7			Detached	4
H40	2	10	7			Detached	5
H41	2+2	22	18	15	10(twins)	Semi	4
H42	2	5	3			Mid Terrace	5
H43	2	12	10			Detached	5
H45	2	21	19	11		semi	4
H46	3	7	5	3		semi	5

Participants in Phase 4: Intervention Evaluation

For Phase 4, the Intervention Evaluation, the participants were selected from amongst those already involved with LEEDR. The trial was limited to nine shower intervention devices. These nine devices had to be distributed amongst as many families as possible, while still allowing for the fact that some families have more than one shower.

One of the fundamental criteria for participant selection, was the suitability of their existing shower for the installation of the intervention device, in this sense it can again be described as purposive sampling (Robson, 2011). The technical data compiled by the LEEDR team was consulted to determine which households might be technically suitable. This created a shortlist of ten households. These households were contacted by telephone to enquire about their interest in participating in a trial of a 'new energy saving technology' for the shower. Three of these families declined to take part at this point, either because they were planning on being away for the duration of most of the trial, or because they felt they had already contributed enough to LEEDR.

The remaining seven families were sent out an information booklet (Appendix C) and cover letter outlining the scope of the trial and the nature of the intervention. At this point one of the households declined to take further part, leaving six households happy to continue with the trial. These families were all based in the area around Loughborough, UK, and the full details of the numbers and ages of occupants, their shower type and the estimated duration and energy consumption of their showering habits can be seen in the Table 3-3 below.

Table 3-3. Details of Selected Participants.

House	Occu-pancy	Shower type	Shower Head Suitability	Jan/Feb Monthly draw off duration (min)	Ages of children
H37	4	1 Elec 1 HWS	Yes	298	>8 - <13
H28	4	1 Elec	Yes	462	Teens
H46	6	1 HWS	Yes	619	Preschool - < 12
H45	3	2 Elec	Yes	719	Teens
H40	4	2 HWS	Yes	380	> 8 - < 13
H43	4	1 Elec/1 HWS	Yes	276/346	> 12 - Teens

Participants in Phase 5: Validation of BISA as a Tool to Guide Design

Phase 5 involved the validation of the BISA developed in Chapter 5 as a tool to guide design. In order to implement this it was necessary to have a controlled environment with access to groups of designers. Other researchers in this area (Lilley 2007; Elizondo 2011; Daae 2014; Escobar-tello 2010) have conducted similar studies in academic environments, and this was felt to provide the best site for this study. The selection strategy was purposive in this respect, but it was also opportunistic; the author was teaching in the university the study was carried out in.

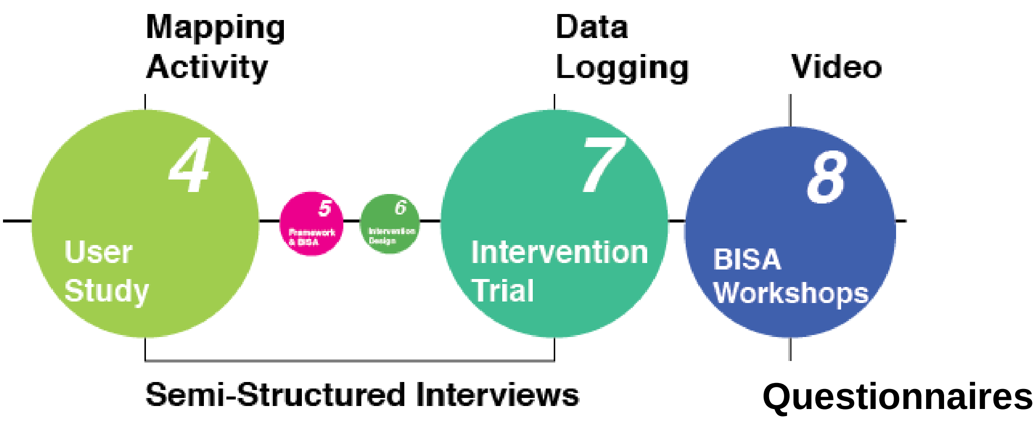
The validation activities were performed with two groups of third year product design students in the National College of Art and Design, Dublin. These groups of students were selected for two main reasons, firstly because the author was able to gain access to them in the course of leading a design project and secondly because they had no previous exposure to DfSB theory. This lack of exposure, it was hoped, would allow a fair appraisal of the usefulness and validity of the framework and theory.

The first group comprised of 13 Irish, 2 French, and 2 German students aged between 20 and 48. The second group comprised of 23 Irish students and 1 French student aged between 20 and 36.

3.6 Data Collection Methods

This section outlines the data collection methods used for the main research studies, as illustrated in Table 3-4.

Table 3-4. Overview of main qualitative and quantitative data collection methods used.



Research Phase	Qualitative Data Collection Methods	Quantitative Data Collection Methods
Phase 2: User Study	• Semi Structured interviews in context • Interactive Mapping Task	
Phase 4: Intervention Evaluation	• Semi Structured interviews in context	• Data logging of date, time, duration, and temperature of showers
Phase 5: Validation of the BISA as a design tool	• Workshop with video, co-operative evaluation • Questionnaire	• Questionnaire

3.6.1 Data Collection Methods for Phase 2: The User Study

Sharing in Context

Firstly the sessions took place with the whole family at home over a take away meal which the researchers provided to the participants' order (after Mateas et al. 1996). The intention of this was threefold; by providing a meal the researchers were redressing the time they were "costing" the family, the sharing of a meal provided a naturalistic way to establish a relationship and build trust in the domestic context (Mitchell et al. 2004), and by giving a non-monetary gift the researchers were engendering reciprocation from the household. These research sessions were called the Getting To Know You, and a research pack was produced (Figure 3-3).

Semi-structured Interview

The second activity was an informal semi-structured group interview held during the meal. Interviews are a method of gathering rich data where the researcher can respond to emergent themes by expanding upon certain issues or moderating the direction of inquiry (Robson, 2011, p280). The themes and questions were prepared in advance, but were selected and modified during the course of the interview to maintain naturalistic flow. Note taking was not appropriate during the meal, so two audio recorders were used, the recordings of which were later transcribed.

The questions that were prepared were based on a number of themes drawn from both behavioural and sustainable design literature. Initially, it was intended to ask many more in-depth questions relating to occupancy, individual practices, habits, and digital media use but the internal iterative testing process showed these would require far too much time and mental energy from the participants.

It was therefore decided to design an interactive activity which would explore some of these issues while engaging the family for the second hour of the session.

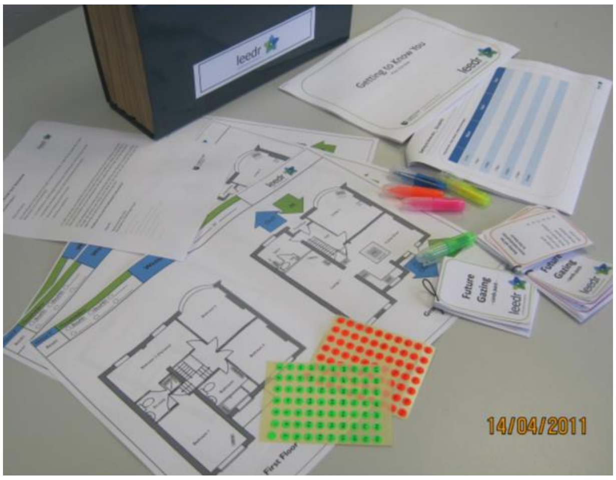


Figure 3-3. Getting to Know You pack

Mapping Routines

"If we see people as creative and makers of meaning, we have to assume that we cannot know in advance what we are going to find in our research. Instead, an interpretive research methodology is needed." (Koskinen 2003)

The third activity was again developed through an iterative design process. It had the ambitious aim of interactively generating an occupancy flow map of the whole family's routines throughout the home during the hypothetical "average" weekday and weekend day. Floor plans of the family home were prepared in advance and the family members were asked to talk through their behaviours on a given day while putting down numbered stickers in sequence. Three sheets were prepared for each day, covering the morning, afternoon, and evening periods. Mapping techniques have been used by a number of researchers studying behaviour, and have ranged from technology based trackers (Aipperspach & Hooker 2005) to "lo-fi" felt board representations of home (Mateas et al. 1996).

In the context of this research the mapping activity is primarily an empathic design tool. Empathic design is a *"research approach that is directed towards building creative understanding of users and their everyday lives for new product development"* (Postma et al. 2012). In empathic design, mapping activities are viewed as *"cognitive toolkits"* (Sanders & Dandavate 1999) which generate *"stories"* which tell us how people understand and misunderstand things, places, and events. Of specific interest to this research into technologically mediated behaviour is their ability to reveal "*the intuitive relationships between system components"* (ibid).

One of the key advantages of the developed mapping activity was that it allowed the researcher to delve into the busy lives of the participants and understand the rhythms and constraints that shape them in a very short timeframe.

Beyond the empathic qualities of the method, the mapping activity was considered important for several other reasons; firstly it provided data triangulation on the verbal responses from the interview (Robson, 2011); secondly it provided a spatial record of occupancy and energy use "hotspots" which could be used to inform both the energy monitoring and possible subsequent design interventions; and thirdly it generated unforeseen responses and dynamics from the family members providing greater insight into the group, and lastly it highlighted the nature of habitual behaviours.

Figure 3-4. Interactive task flow plans

The final design of the activity consisted of a set of floor plan drawings of the home (one for morning, afternoon, night) for both weekdays and weekends. Each family member was given a set of numbered colour specific stickers which they could lay down in sequential order as they talked through their "typical" day. The activity produced a set of "flow plans" (see Figure 3-4) which provided a graphical record of a self-reported weekday and weekend day. The complete interview pack can found in Appendix D.

3.6.2 Data Collection Methods in Phase 4: Intervention Evaluation

While the research study conducted in Phase 2 can be viewed as being formative in nature, with the results informing the rest of the research activities, the evaluation of the design intervention can be classed as summative. Summative evaluation occurs at the end of the research period and concerns itself with the effect of the research activities undertaken (Maguire 2001). In this case, the research undertaken was the user trialling of the designed intervention in the context of 6 participant homes. The user trial seeks to determine the functional success of a design, taking into account behavioural, technical and contextual factors (McClelland & Suri 2005; Lilley 2009). As well as determining the success of a given design, user trialling is also used to highlight the as yet uncovered shortcomings or failures within a design. In this respect, user trials can be viewed as an integral part of the iterative design development. The intervention trialled in this study went through two stages of user trialling; a single pilot test which resulted in design iterations, and a medium term multi-household evaluation. These are detailed further in chapter 7.

In line with the exploratory nature of this entire research study, qualitative means were used to gain insight into the nature of the effect of the intervention, and to uncover unforeseen user responses and dynamics (Robson 2011). This took the form of semi-structured interviews, taking place in the family home with the entire family at the end of the trial. As described in previous sections, this flexible form of enquiry allows the researcher to respond to emergent themes and the group dynamic leads to greater cross-interrogation and exploration. The interview was structured around a range of themes relating to attitudes, emotions, and behaviour before, during, and after the intervention. The interview guide can be found in Appendix E. The interviews were recorded on two audio recorders and were transcribed.

In addition to the qualitative enquiry, the review of the literature highlighted the need for robust quantitative measurement of energy consumption data to ascertain whether or not the intervention had resulted in a reduction in consumption. This led to the development of an intervention (described in detail in chapter 6), with a built-in data logger which recorded date, time, duration and temperature of all showering events (the chosen intervention target). This combination of both qualitative and quantitative measurement can be described as a mixed methods approach (Robson 2011), and is common within flexible research.

3.6.3 Data Collection Method in Phase 5: Validation of the BISA as a Tool to Guide Design

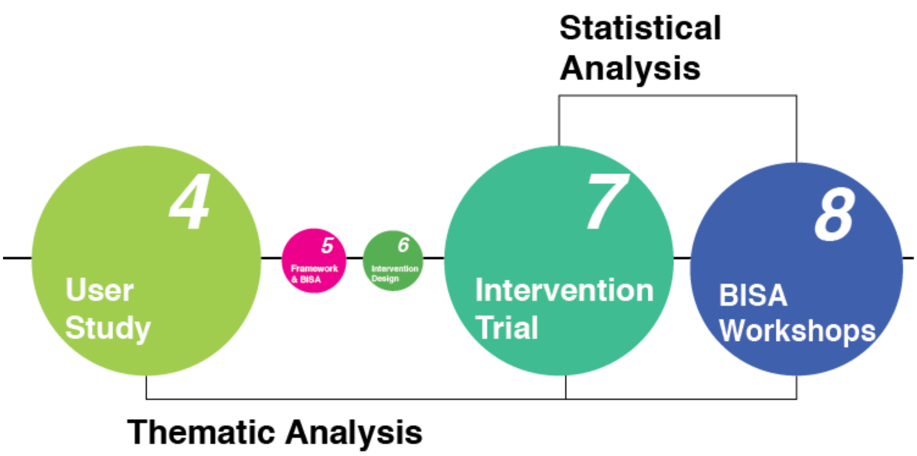
In order to gain 'deep insight' into the suitability of the BISA developed in chapter 5 as a tool to guide design, workshops were held with student designers in NCAD, Dublin. Design workshops have been used by many researchers in this field as a way of testing and validating theoretical developments (e.g. Lilley 2007; Escobar-tello 2010; Daae 2014). The primary form of data collection used was observation, in the form of 'participant as observer' (Robson 2011). This method required the researcher to participate in the activity to be observed, in this case to lead and take part in a DfSB workshop. At certain stages of the workshops a method of 'cooperative evaluation' (Monk et al, 1993) was employed where the participants were asked to verbalise their thinking and reasoning behind the decisions they were making using the BISA.

To allow the researcher to wholeheartedly engage in the workshop delivery and participation where necessary, the workshops were documented through video and photographs for later analysis. In addition, the second of the two workshops involved the use of a questionnaire document which consisted of a series of questions using a 5-part Likert scale with space for the participants to add comments and suggestions in their own words. A detailed overview is provided in Chapter 8.

3.7 Data Analysis Methods

This section outlines the data collection methods used for the main research studies, as illustrated in Table 3-5.

Table 3-5. Overview of main qualitative and quantitative data collection methods used.



Research Phase	Qualitative Data Analysis Methods	Quantitative Data Analysis Methods
Phase 2: User Study	• Thematic Analysis	
Phase 4: Intervention Evaluation	• Thematic Analysis	• Statistical Analysis
Phase 5: Validation of the BISA as a design tool	• Thematic Analysis	• Statistical Analysis

It can be said that there is no universally agreed upon method to best analyse qualitative data. However, in a substantial review of the field Creswell (2007) identifies a number of features common to successful analysis. These are data managing, reading and memo-ing of the data, describing the study and context, classifying the data into themes and codes, interpreting these themes and codes within the context and finally representing or visualising the data in matrices, trees or propositions. Creswell terms this the 'data analysis spiral' (see Figure 3-6) in which the researcher "*engages in the process of moving in analytic circles rather than in a fixed linear approach"* (Creswell 2007, p.150).

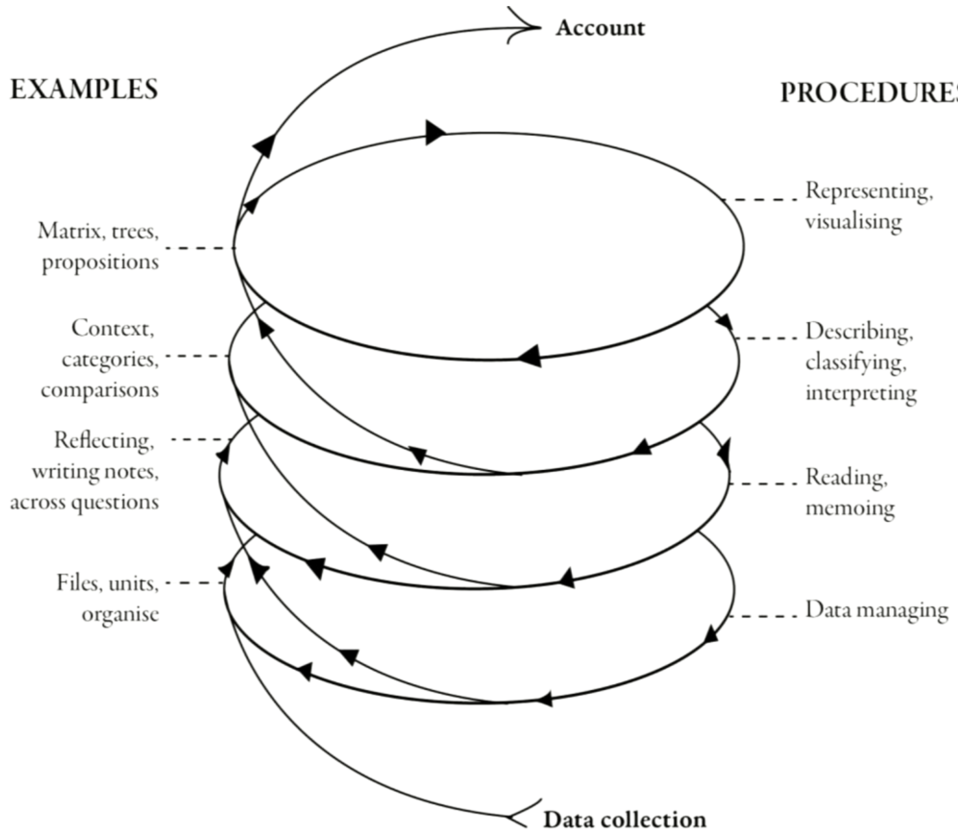


Figure 3-5. The data analysis spiral (Creswell 2007, p150).

3.7.1 Data Analysis methods used in Phase 2

Thematic Analysis

The audio recordings of the 20 semi-structured interviews conducted in phase 2 were transcribed for further analysis. At over 200,000 words, such a large body of data requires a method of analysis which allows the researcher to: reduce the data to manageable units, display the data in a meaningful way, and to draw conclusions from the data (Robson 2011). One such method is thematic analysis (Braun and Clarke 2006) or thematic coding analysis (Robson 2011).

At the heart of thematic analysis is the coding of different elements of the gathered data into key terms which *"exemplify the same theoretical or descriptive idea"* (Gibbs 2007, p 38). These codes can be generated by the researcher based on their knowledge of the literature and the research type before the analysis begins and searched for within the data. This form of theoretically driven coding is what Robson (2011) calls "*a priori*" coding. Alternatively, the coding can be driven inductively by interesting emergent patterns within the data which are identified and coded as they are identified. A full thematic analysis of the transcripts was undertaken solely by this researcher and both methods of coding were employed within this analysis.

As these codes were generated, potential groupings or clusters of codes began to emerge which can linked under what can be termed themes (Braun and Clarke, 2006). Themes are higher level groupings of codes which start to allow patterns with-in the data to be viewed. Both codes and themes can be generated by analysing data at a "*semantic*" level, i.e. based on the overt description contained in the data, or at a *"latent"* level which examines the underlying ideas and assumptions at a theoretical level (Braun and Clarke 2006).

Given the very large quantity data in this study, Nvivo qualitative analytical software was used to code the transcripts and define the themes of the study. An overview of the themes identified can be seen in Figure 3-7, each of which contained a number of related codes. Though performed solely by this researcher in the furtherance of this piece of research, the thematic analysis also sought to accommodate the requirements of the larger LEEDR investigation. This lead to the identification of a number of wide ranging themes that often exceeded the scope of this thesis. The full thematic analysis of the study can be found in Appendix F, and selection of the relevant themes are discussed in detail in Chapter 4.

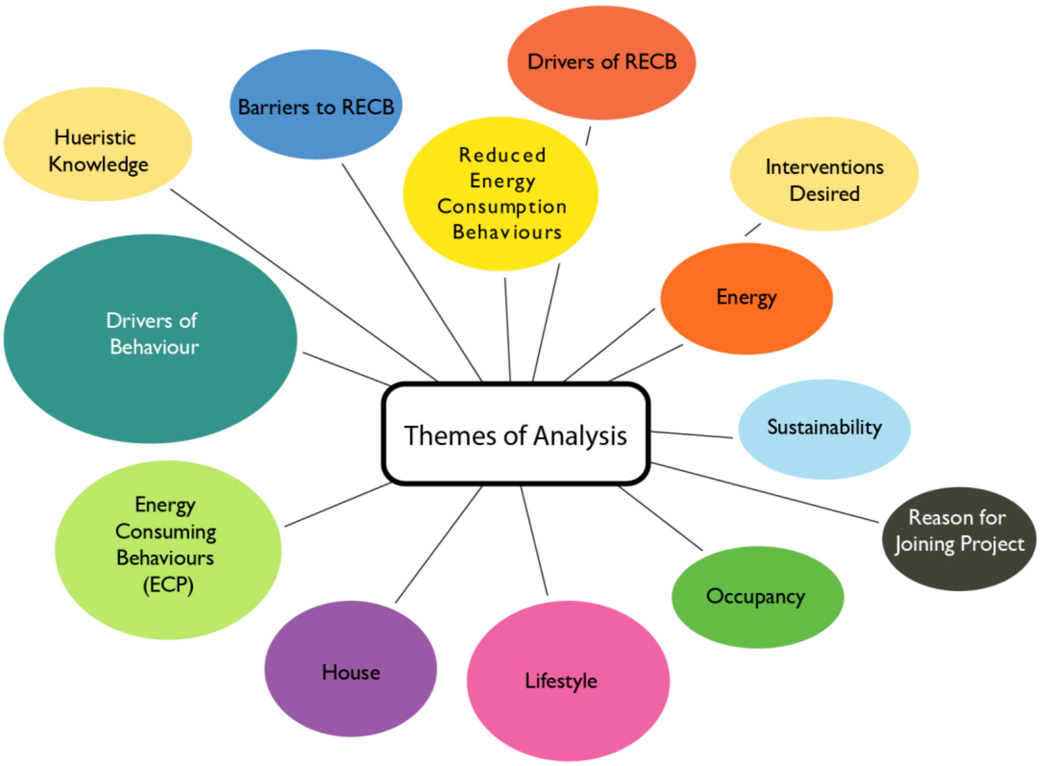


Figure 3-6. Overview of all themes of from Phase 2: User Study.

3.7.2 Data analysis methods used in Phase 4: Design Intervention Evaluation

Thematic analysis

The summative semi structured interviews undertaken in Phase 4: Design Intervention Evaluation were transcribed and analysed using the same thematic analysis method outlined in section 3.7.1 above. There was however one main procedural difference; because the quantity of data was much smaller it was possible to code and sort the data manually using Post-It notes rather than the Nvivo software used previously (Figure 3-9). This was done to avoid one of major pit falls of using specialist Qualitative Data Analysis packages outlined by Robson (2011, p 472); the difficulty or reluctance they can effect with regard to changing or recategorising developed codes and themes. Using Post-It notes in this manner allowed for rapid and iterative coding and theming of the data, which went through several cycles before being written up in the form presented in Chapter 7 and Chapter 9.

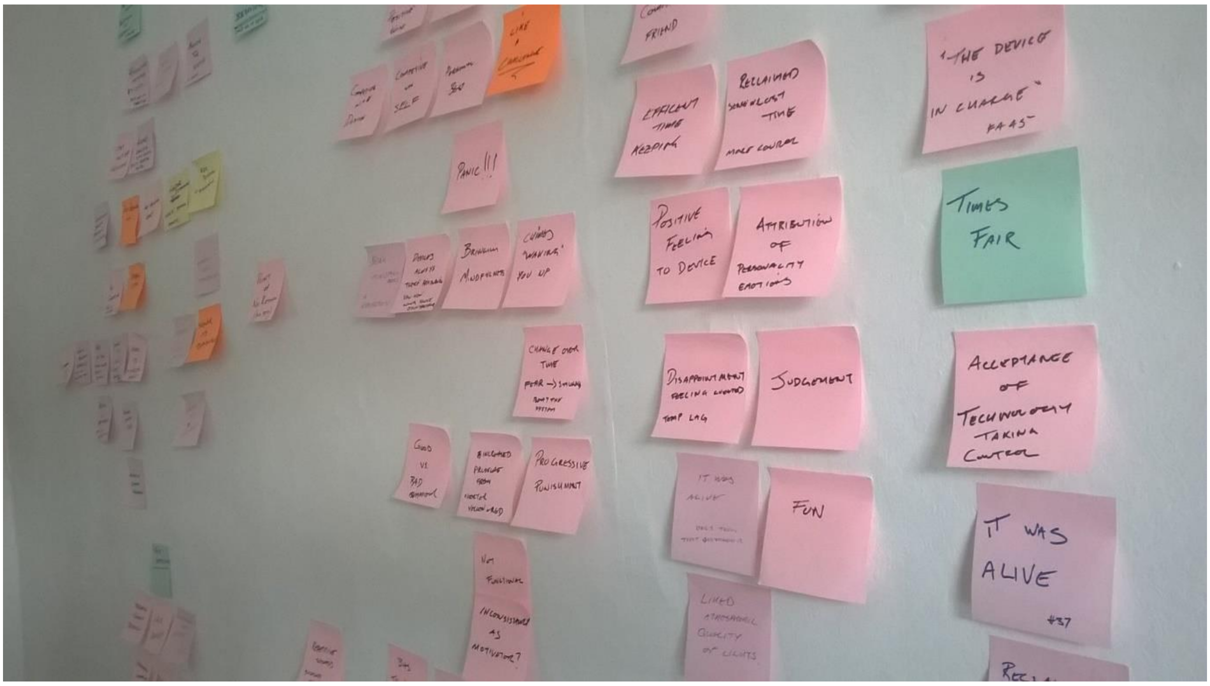


Figure 3-7. Post-It note coding used the analysis of Phase 4: Design Intervention Evaluation.

Quantitative analysis of data

As the intervention evaluated in Phase 4 also recorded quantitative data, this was analysed in Excel using basic statistical methods including counts of frequencies, proportions, and central tendency (Fink 2003). The data was primarily displayed visually in scatter plots or comparative donut-charts as these forms best conveyed the key metric: the change of behaviour over time.

3.7.3 Data Analysis Methods in Phase 5: Validation of the BISA as a Tool to Guide Design

Analysis of the video data from design workshops conducted in Phase 5 was analysed using the coding method outlined in the previous two sections. The scope of this study was much smaller than those preceding it and the data could be coded and sorted in word processing software using a combination of *a priori* and emergent codes.

In addition, the second part of this research phase employed questionnaires using a Likert scale, the responses were quantitatively tabulated using the basic statistical methods of proportioning and displayed in bar charts. It was decided not to analyse this data using averages or standard deviation as the bar charts provided a clearer view of the actual range of responses. The full analysis is presented in Chapter 8.

3.8 Design Research

Phase 3 of this research involves the design of an intervention to be tested in the participants' homes. While the design process follows the User Centred Design approach outlined in section 6.1, in this research it is also used to crystallise the theoretical work into a physical hypothesis to be tested (as per Koskinen 2011, p60). That is to say, the aim of the design intervention development is not just the creation of a product which stands for itself and can be critiqued solely against its design specification or the rigor of the design process in achieving this. This does not mean that the resultant artefacts will not be innovative or successful (they may well be considered so), but rather that the design work is also a means of testing the conceptual frame work and building theory.

"When researchers actually construct something, they find problems and discover things that would otherwise go unnoticed." (Koskinen 2011, p2)

While the User Study has generated a large quantity of data around existing behaviours and the intentional aspects which drive them, it has only described *things as they already are*. What it cannot do is give a valid understanding of *how things might be.* While designers inherently imagine these future states of being and conceive products which might give rise to them, they can only actually be realised through the creation and trailing of functional design interventions. In this sense the intervention design study has a number of roles to play in the research at large; it acts as part of case study to test the hypotheses developed in Chapter 5, it generated quantitative energy use data, it led

led to the creation of an innovative artefact, and it embodies new methods of changing user behaviour.

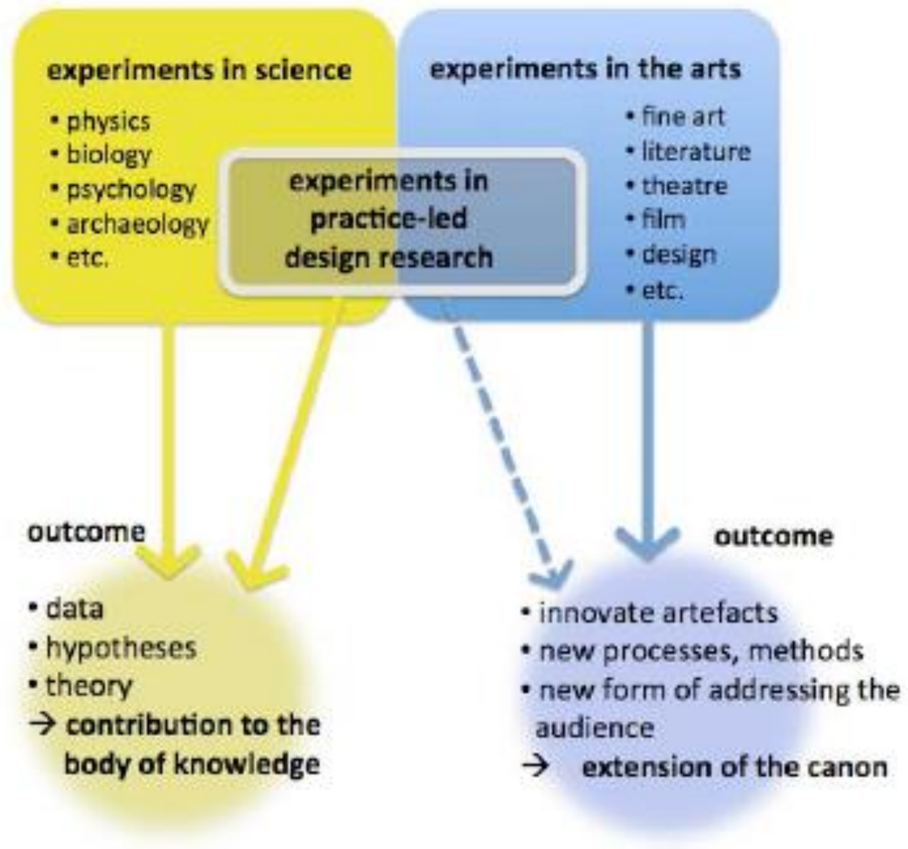


Figure 3-8. Outcome of experiments in science, arts, and in practice led design research, (Steffen 2013).

This element of the research sits firmly in the category of "experiments in practice led design research" as defined by Steffen (2014), see Figure 3-9. It is a category that straddles experiments in the arts and the sciences which shares commonalities with both. This categorisation rightly gives due weight to the abductive reasoning inherent in design synthesis, and acknowledges it as a valid element of experimentation. Abductive synthesis will inherently lead to the creation of a design intervention which appears to move beyond the evidence which gave rise to it and into a less evidence based, more speculative realm. This is inevitable as the designer draws on past experience, forms hunches, and imagines future scenarios. This does not, however, weaken the empirical rigor of the research if a comprehensive evaluation of the design intervention is undertaken to ascertain its true effect (ibid). This evaluation will be described in Chapter 7.

3.9 Ethical Issues

A thorough ethical procedure was put in place by the LEEDR project management, which received clearance from the Ethics Advisory Committee of Loughborough University. It included a project risk assessment, and the provision of information sheets and consent forms to participants (see Appendix G). All participant information was totally anonymised, and stored securely. In addition all researchers performing field work had an Enhanced Disclosure check by the Criminal Records Bureau. These procedures were followed rigorously throughout the research process.

4. User Study

4.1 Introduction

This section outlines the aim, and methodology of the user study undertaken. It goes on to detail the findings drawn from the collected information and positions them in the wider field of the research.

4.2 Aim and Objectives of the Study

The study had the following research objective.

3. To gather domestic energy behaviour data through a qualitative contextual study of real people.

To achieve this, the study needed to uncover the situational and motivational drivers of energy consuming behaviours (ECBs) of the participant families. It needed also to uncover patterns of habitation and related energy consumption. Key in testing the conceptual model was identifying the relevant barriers to reduced energy consumption behaviours (RECBs) across the participants. These findings should provide clear criteria for the design of energy demand reduction interventions.

4.3 Implementing User Study

To ensure that obstacles and lack of participant compliance known anecdotally to have been encountered by other researchers in this area were avoided, the research study was first iteratively developed and trialled “in-house” by the researchers to test and evolve the methodology and design. This is what Yin (1994) terms a pilot test but might be more generally classified as preliminary case study where some of the research questions are methodological (Robson, 2011, p142). The reason for this early iteration was the desire to build a detailed picture of participant lifestyles, energy awareness, future aspirations, and habitual occupation patterns in a very limited timeframe while making the process a pleasant one for the participant. The format arrived at through this internal process, was then put forward to a “real world” pre-test (Yin, 1994) or pilot test (Robson, 2011) with the parents of a local familiy. It was termed The Getting to Know You (GTKY) interview, and was a combination of the three main activity strands discussed in section 3.6.1.

4.3.1 Changes to the Pilot Study

Following the pilot study the participants were asked for their feedback on the process. Overall their response was very positive, having found the experience both pleasant and enlightening. Some changes and recommendations to the interactive task were made by the researchers, these are as follows:

1. Include the garden(s) on the floor plans to capture activity there.
2. Ask primarily about a hypothetical winter’s day, with a brief overview of the main differences in summer.
3. Researchers were unable to successfully take detailed notes while facilitating the task, and so should just rely on the audio recording.
4. Some further procedural changes were made to the preparation check-list with a view to streamlining the process and maintaining consistency across the participant group.

4.3.1.1 Participant Selection Information Pack

One aspect of the feedback from the pilot studies was a sense from both participants that there was far more time required by the study then they had imagined, and that some the questions and information they were presented with were too complex. They went further to suggest that had they not already known the investigation researchers they would not have continued with the study. This was related to the research activities carried out the other departments and not specifically the GTKY, however the knock on effect of participants leaving would have jeopardised our own research. As such, it raised a very serious point about the accurate disclosure of the nature of the research activities and the time required by the participants prior to their signing up to the study. To this end, a comprehensive information pack (Appendix B) was designed which included a concise colour coded A5 booklet and a complementary range of more detailed information and consent forms. Also included in this were images of all the researchers doing field work, which it was hoped would both add a human face to project and help engender familiarity and trust should the participants sign up.

4.4 Findings

4.4.1 Introduction

What follows is an edited selection of the findings drawn from the thematic analysis of the interviews held with the twenty households (see Appendix F) conducted by this researcher. The selection of the findings included here is based on their relevance to this thesis and the subsequent research activities contained herein.

4.4.2 Drivers of Energy Consuming Behaviour

All energy consumption is in some way driven by motivations on the part of the occupant, however the actual energy consumed is not always directly related to the occupants' motivation but can more incidental. This section looks at some of the factors which drive these motivations, and some of the factors which give them shape.

Comfort

> *"I mean you'd like to think you're saving the polar bears and what not by sitting with the heating off, but if the heating's there you're going to turn it on."*
> ***H01FAc1***

Comfort was a very strong motivator for occupant behaviour, and was spoken of particularly in terms of thermal comfort. Indeed all the participants' homes were centrally heated, and were all maintained to a level that was deemed comfortable by (most of) the occupants. Standards of comfort were not constant, but rather were subjective and changing depending on other factors. While it may seem self-evident to say, people have certain comfort base lines below which they will not go unless they can't help it. This is a key principle to bear in mind when seeking energy consumption reduction (ECR), as most of our participants had the means and the access and could all afford to maintain their current comfort levels as they were. However, this doesn't preclude the introduction of alternative forms of comfort such as personal heating solutions.

Convenience

> *"I'd say its convenience, isn't it, I think. It's the dishwasher, the washing your clothes. That's all convenience, ain't it? The information, like you say you could go to books, but it's so convenient, ain't it, you just press a button."* ***H09MA***

Excluding perhaps the most basic requirements of heating and lighting necessitated by the British climate, convenience is one the strongest primary drivers of energy consumption. It pertains strongly to time available and to effort required for any given behaviour, with the latter being dominant. It is also inexorably tied into the specific design and physical proximity of the appliances available, both in terms of how convenient they are to use or interact with but also in terms how much effort they save the user. At a very basic level, both of these strands can be illustrated by the habits and practices that have formed around the power standby feature on modern TVs.

Where previously TVs had to be physically turned on or off at a physical electrical switch on the device, modern sets can be controlled with a remote control which incorporates a reduced power-state standby control. This standby feature allows the TV to re-powered up from the couch without making the effort to walk over to the device (proximity), furthermore many modern TV sets have hidden the physical electrical switch at the side or back of the unit making harder to find and use (interaction). As such all of the participants used the standby mode to some extent (in some cases only during waking hours) as it was by a large margin the most convenient and immediate way to control the TV. The flip side of this that most TV sets still draw considerable current in standby mode, so this convenience for the user consumes a lot of energy by default. Interestingly several of the participants were very aware of this energy consumption and made some efforts to reduce it switching off at the plug at night, but no one reported not using the standby feature while at home and awake.

While the standby on TV sets is a simple example of how if an appliance saves occupants effort and makes a particular behaviour more convenient than another it will often be used, the same principle applies to most appliances in the home. The traditional large “labour saving” devices like washing machines, tumble dryers and dishwashers are explicitly created for this purpose, and while none of the participants even considered not using a washing machine for clothes (the alternative, hand washing, was far too labour and time consuming), many were aware that the tumble dryer was not a strict necessity but it was often just far too convenient to pass by.

These particular labour saving devices are explicitly bought for their very convenience, but often this convenience driven behaviour is often far more hidden or tacit and is so strongly tied into the affordances of the available appliances and system that participants rarely even commented on it. Central heating systems for example are by definition more convenient than separate fires or heaters in every room but are rarely viewed as a labour saving device. They exhibit a lack of proximity in that they are composed of many elements dispersed around the home, each interfacing with a number of different variables (such as external temperature, draughts, doors, etc.) and thus creating a complex interaction. As such the most convenient behaviour is merely to let the system come on and heat all the radiators that are switched on regardless of whether the room was actually occupied, behaviour very common amongst the participants. Even those that were conscious of this fact admitted to not regularly making an effort to move around the home to optimise heat use.

The participants were keenly aware of their fondness for appliances that made life easier and the extent to which their lives were built around them; in broader sense this has been the main direction of domestic appliance design for the last century.

In this case, many participants felt that the main reason their energy bills were so high was because they engaged in the convenient behaviours, the tasks that "make life easier". This points towards a positive reception toward being "allowed" to continue with the convenience driven tasks if reductions are made in terms of basics utilities.

Cost

> *"I hate to say it, but as you perhaps have a little bit more money, you tend to care less about those things unless it's very, very ingrained within you. So it's there in my mind, but I hate to say, if I'm cold now I just put on the heating."* ***H45F***

The cost of energy, as relayed through utility bills and direct debits, has a complex relationship with the consumption of energy in the home. On one hand cost is often given as the main motivation in reducing consumption (see 4.4.3 Drivers of Reduced Energy Consumption Behaviours) but on the other the cost of energy is often seen as acceptable in comparison to how it enriches householder's lives. This appears to be strongly linked to the relative expenditure on energy compared to household income i.e. if we can afford it, it's not a problem.

When money was a more pressing concern or even a worry, participants reported being very conscious of minimising the cost of energy use. This does not always develop into a sustained habit, and can be discarded for more profligate consumption patterns when cost ceases to be an issue.

Even amongst participants with an interest in reducing bills there are often more pressing issues which take precedence over just saving money. These issues often have more immediate and tangible consequences than the cost of energy use.

This is a good example of the manifold concerns of family life being expressed through the available contextual features, in this instance at the expense of cheaper electricity use. The GTKY interviews provided good insight into these concerns but they are too varied and numerous to categorically list or predict. Thus when designing interventions, it becomes necessary to take account of those we know, but also to build in the flexibility which will allow users to fit them into their own unique lives.

Multiple Occupants

> *"We do that, because I turn it up, and then he turns it down, and then I turn it up, and then he turns it down"*
> ***H38FA***

While all energy is consumed by people, all our households were composed of several different people, each with the own role to play in its consumption.

Much energy consumption was driven by the different needs, preferences, and routines of occupants in a shared home. This manifested itself in many different forms, but all had the shared result that more energy was being used than might be possible because one occupant or other behaved in a different manner or had different needs. This is not to say that their behaviour was improper in any way, but merely that it had a noteworthy impact on energy consumption.

In a number of cases the participants reported having different standards of thermal comfort which generally led to one occupant determining the heating settings for everyone, or led to thermostat battles where the temperature was being set up and down by different occupants.

It is often the case that some occupants engage in activities which are disturbing or uninteresting to other occupants and these conflicting activities lead to dispersed activity. This will always be a feature in a shared house where individuals have separate interests, but it is perhaps worth examining in terms of energy use and possible routes to consolidating occupancy.

In one case a participant's mother lived in a semi-autonomous "granny flat" attached to the house, an extreme (though far from unique) example of different lives with different needs and routines sharing a home. This house with three generations living it gives a good indication of the complexity of occupant energy use. In this case the children were readied for school in the sitting room in front of a large energy-hungry plasma screen

TV. The TV was used to keep them calm while their mother got them ready, but it also gave off a lot of heat which would make the room warm. While it may have seemed obvious to target the inefficient TV as a waste of energy, here the grandmother moved in from her flat to the warm room rather than turn the heating on in the whole house.

Parenting and Children

> *"It's quite hard to be conscious of the energy you use when you've got young children"* **H18MA**

It may seem self-evident to say, but much of the energy consumed in families is driven by parents trying to look after their children's needs and desires. They are faced with a huge increase in the amount of work required and are often trying to meet these needs in a constrained time frame. The children themselves also have a direct impact on energy consumption, though at a younger age this is not often too significant.

There was evidence of significant structural and behavioural changes due to parental concern over their children's health, particularly when children were very young. These changes ranged from closely monitoring temperatures and changing heating usage to structural changes including insulation and carpeting.

These health driven changes to energy consumption were particularly true in families with young or new born children. Having a child is obviously a huge disruption in lifestyle, and leads to dramatic changes in many aspects of behaviour. Whereas previously participants had developed their own routines and practices regarding heating and hygiene, for example, in many cases these were totally reinvented to better protect the children's health and wellbeing. As these changes were generally made based on advice from doctors or health services (it is standard NHS advice to maintain temperature around 18˚C), they illustrate how parents are prepared to rescind their own standards of comfort to follow a very different set of guidelines for the good of their newly arrived children. While several of the parents spoke of growing up in cold unheated homes, none of them expressed an opinion that it hadn't done them any harm and that it would be fine their own children. Different heating regimes are often put in place for new born babies; however it is unclear if or when these revert back to the original heating plan.

However it should be noted that not all changes made resulted in increased energy use, in one instance a family who had previously kept their home very warm changed to a much cooler temperature based on medical advice.

Social Norms

> *"Because our bills aren't that extortionate… They're high enough, but because we know that we're still below average, then there is a little bit of leeway in there and, like I say, its comfort and convenience over cost."* ***H10FA***

Social norms in terms of energy consumption are a double edged sword, on one hand they can act as a motivation for high consumers to bring their consumption down. However for those who are at or around the average level of consumption it can act as a form of validation of their energy consuming ways. This is an issue because the current average energy consumption is still far too high, and needs to be reduced substantially to meet legal obligations agreed to by the government.

Time

> *"I think the routines can change provided there is time in the day to do that. If the routine then requires more effort in order to save electricity or whatever, then it's going to be difficult to get that into our busy lifestyle."* ***H01FA***

Time, or more precisely the lack of time, has a huge impact on the choices people make. As was already mentioned in the previous section on children, families are increasingly pushed for time as they try to combine family and work life. For families with younger children this is particularly the case as they often require a huge amount of care and time to be spent over tasks like eating, washing, laundry etc. Furthermore time is a finite resource and is less subjective than, for instance, comfort or convenience.

Almost all participants claimed to lead busy lives and to have little spare time available. All said that while they would be willing to make an effort to reduce the amount of energy they use, they would not be prepared or able to consider any intervention approach that consumed a significant amount of time.

Theories of How Things Work

> *"That's we why don't have doors in this room and we tend to leave the doors in the lounge open and obviously the hallway…. in theory it should mean the heat rises, but it doesn't quite seem to do that."*
> ***H18MA***

Participants often illustrated an understanding of technical systems that was not strictly correct. This is a natural interpretation of phenomena based on observation but it highlights how the creation of mental models can cause a system to be used in a particular way which might not be the most efficient. In one case a participant would leave all the doors open downstairs when the heat was on in an effort to get more heat upstairs. This was to combat the cold upstairs he felt was caused by the poor insulation, the fact that he was simply pouring more heat, and thus more energy, up through the roof didn't enter his mental model.

There were also several interpretations of the nature of control between TRVs and the heating thermostat which might lead to unnecessary energy consumption.

4.4.3 Drivers of Reduced Energy Consumption Behaviours (RECBs)

The interviews uncovered a number of drivers behind participants desire to reduce energy consumption. These were a mixture of ideological reasons and experienced learnings, but foremost amongst them was a financial motivation to reduce the cost of energy bills. There are always some limitations to information gained from a reflective interview like this, which doesn't necessarily convey the dominant motivations of participants while they are actually performing the activities which consume energy.

Nonetheless, these drivers are the ones which would appeal to occupants particularly in the uptake of any design intervention.

Cost

> *"So it is quite hard to feel empathy sometimes to saving energy other than for the sake of saving money."* ***H18FA***

The rising cost of energy bills and their proportion of household expenditure was far and away the strongest motivator to reduce energy use amongst participants. As shown previously (see 4.4.2 Drivers of Energy Consuming Behaviour/Cost) cost has a dynamic relationship with energy use, often dependant on the percentage of income spent on it, and would not be a strong motivator for everyone. However, in this sample most people were keenly aware of the cost and very eager to make some savings if possible. Indeed many of the participants listed it as their only real motivation to reduce energy consumption in the home.

The impact of energy costs are felt especially by families with young children, this is compounded by the fact usually one parent has stopped working with the arrival of the child and is now spending a lot more time at home. This leads to a significantly reduced income combined with increased energy bills. Furthermore new parents have so much on their plate that it can be difficult take energy reduction in to account while trying to fulfil their new parental role.

The nature of how this financial motivation expresses itself is a key concern for any intervention strategy. It would appear that it varies across the sample, with some self-described "skin flints" claiming to be conscious of expenditure all the time and taking appropriate action on an on-going basis, whereas others would admit to receiving a rude awaking with the quarterly bill. This range of awareness and positive action requires different design approaches, or at least a design approach which supports both continuous action and more infrequent but dramatic energy reduction.

The dramatic impact caused by increased bills is a very strong prompt to engage in REC behaviour and should be fully utilised by any design approach. It could lend itself to an intensive “energy boot-camp” approach where occupants could be engaged into a whole series of actions involving target setting and commitment strategies. It is crucial that the durational aspect of these activities are maintained through prompting and support, as otherwise it is likely they will fall away as the impact of the bill is lessened in time.

Such a cost focused approach requires the use of significant and meaningful metrics to sufficiently engage users. For example, it is unlikely that users will be motivated not to use the oven to heat their dinner if promised a saving of 7.3p by using the microwave. Extensive user testing of any cost centred metric is required to ascertain what is meaningful to participants.

Efficient Design

> *“Because our washing machine broke so we had to buy a new washing machine and …we did look at the energy rating on the new one and we ended up buying one that was £100 more than the one that we’d chosen largely because it had a better energy rating and also the programmes were shorter.”* ***H08FA***:

Distinct from other motivations to reduce energy use was an appreciation of energy efficient design as expressed by some participants. While certainly strongly influenced by reduced cost this was also based on an attraction to elegant design and low energy systems.

While this may not be a universal motivation in any terms, it does seem relevant to the desire to engage with any new design intervention. Accordingly, the workings and reasoning behind such interventions should be made accessible to the user to appeal to this motivation. Obviously such an explanation is required in addition for a number of other reasons, such as ensuring proper use.

Environmental Concern

> *“Yeah because I do kind of buy into the idea that we all live on this planet, that it’s loaned to us and we care for it and I have children who are going to live beyond my*

years and I want them to have an environment that they enjoy.” ***H33FA***

While many of the participants were aware and concerned about the environment, relatively few gave it as a major motivation to reduce energy consumption.

While environmental concern appears not be a very strong motivating REC behaviour at the moment it should not be disregarded. It is an issue that is likely to continue to grow in relevance over time, and has a permanence that financial motivations do not always sustain. It may be possible to strengthen environmental concern through persuasive design by the provision of information and the leveraging of norms and parental concern. However it should not be the primary design focus but rather a supporting or optional path of engagement, as it remains an intangible concept for many.

Upbringing

“But yeah, going back to the energy side of things, I think… The energy side of things I think with myself it’s sort of stemmed from my parents sort of thing. You know, like your parents always used to tell you “Turn the lights out,” do you know what I mean?” ***H41MA***

Quite a few of the participants spoke of being raised to be very conscious of energy use, generally for financial reasons. What is particularly interesting is the long term nature of this awareness, which comes across being completely ingrained in these participants.

This illustrates how lessons learned and repeated in childhood can have long term effects, and points towards design interventions aimed at engaging children into RECBs. This is obviously an area requiring a high degree of ethicacy and tact, but there is nothing inherently wrong with empowering children to reduce the family’s energy use. Many parents would acknowledge the strength of “pester power”, and in some ways change might come more successfully from within the family.

4.4.4 Barriers to Reduced Energy Consumption Behaviour (RECB)

Even though their participation in the study illustrated a willingness to reduce energy consumption amongst the participants, there were still a large number of real and perceived barriers which reduced their ability to do so. This section looks at these factors through this lens, even though a number of them are related to those covered in previous sections.

Aesthetics of Low Energy Technologies

> *"you can get it looks like thick wallpaper but it's some sort of insulation. And so that's in Bethan's room, but it's not… particularly attractive and we thought "We don't really want that in our living room,"* ***H39MA***

A number of participants expressed distaste for the aesthetic quality of many low energy technologies. This is particularly true where a low energy technology is purely functional in design, but this is at odds with the majority of domestic purchases which are chosen with some aesthetic or sensory consideration.

Comfort Baseline

> *"I'm quite happy with where we are sort of trying to minimise use, but not going completely out of your way to be uncomfortable, shall we say."* ***H10MA***

Strongly tied to Comfort as a Driver of Behaviour but in an inverse sense, it was made very clear by many of the participants that there was a level of comfort that they considered to be a minimum and would not be happy to go below. This was often talked about in terms of thermal comfort but more so in a general comfort of living. Interestingly this was often mentioned by participants who were already very conscious of their energy use and indicates a considered opinion based on serious thought.

Conflicting Occupant Behaviour

> *"You made us buy a blooming tumble drier and I refuse to use it."* ***H05FA***

It was clear from the interviews that all occupants of a household did not share a common policy on the appropriate level of energy use. This can be viewed as a serious obstacle to introducing RECB as it increases the numbers of actors needed to comply with any given behaviour change. Often as not, it is not some ideological departure that causes different occupants to behave more or less energy intensively, but rather it is individual lifestyles and preferences. The following examples are all taken from one fairly typical family to illustrate the many various impacts that conflicting occupant behaviours can have.

Confusing Information and Tariff Complexity

> *"I tried looking at it to change providers and I just didn't really understand what it was I was comparing, which I don't know whether that's part of their plan – to confuse us all completely" H18FA*

One of the biggest barriers to understanding energy use was the confusing manner in which energy information is relayed by providers. It is not just the disconnect between units and kWh and actual energy usage but also the complexity of the way tariffs are relayed to the consumer. There was a sense that this was often a deliberate ploy to keep consumers paying more than they need, and it certainly would have an negative impact on demand shifting as most participants struggled to understand the nature of the their own usage and how it would align to any price plans like Economy 7.

In some respects this confusion over energy and tariffs could be seen to be reducing the amount of energy consumed by keeping the cost higher than it could be, but in reality it inhibits the occupants from really engaging with subject of energy use. If they cannot understand the implications of what they are doing on their energy consumption they are unable to make informed decisions about how they could reduce their use. There is a chronic lack of feedback about the whole process which prevents the consumer from making the changes in their every day practices. This especially applies to the direct debit system of payment operated by many energy providers, which disconnects actual energy use from the billing cycle through its annual cycle.

Convenience Baseline

> *"I put the tumble dryer on all the time because it's convenient ... Yeah, I'm aware it uses a lot of electricity and it's not environmentally very sound, but I want dry clothes and I want to be able to fold them up and put them away"* ***H43FA***

Closely related to the Comfort Baseline explained above, there was a strong sense that participants would not voluntarily go beyond a point at which they would make their lives untenably difficult. This becomes particularly pressing when parents have younger children who generally require a lot of time anyway. Most commonly mentioned were labour saving devices like dishwashers, washing machines, and tumble dryers which spare a huge amount of time and effort. Interestingly there was often a fear that design interventions would target these appliances, particularly from mothers of families (who, in our sample, did the majority of domestic tasks). This implies that while they know these appliances consume a lot of energy, they find them to be so integral to their lives that they couldn't give them up.

Contextual Barriers

> *"Standby buttons on our upstairs telly because ... other than switching it off at the plug, which we can't get to because there's something in front of it, there's no way of switching it off,* ***H38FA***

Though not necessarily the focus of the interviews, several of the participants spoke of contextual barriers in the home which hindered them from using less energy. This is of particular note as it is likely that all homes have unique features which affect the energy efficiency of appliance use or prevent occupants from taking greater action. Some of these are fairly widespread, such as digital media suites being stuck on standby because of inaccessible plugs. Others are perhaps less common, through probably far from unique, like thermostats situated near heat sources or poor wireless signals.

Forgetfulness

> *"When you've been sitting here with the children for an hour doing something at the table you think "Oh, the TV's still on in the other room!" I'm always forgetting"* ***H18FA***

A commonly mentioned barrier to RECBs was a universal human issue; forgetfulness. While obviously this is something that will always be an issue in any activity, what it means for energy consumption is that even if people are keen to reduce their usage they may end up not. People often spoke about forgetting to turn off lights, but this is presumably because lights are very noticeable when found on and it is likely that many other appliances are often left running too. This is not limited to switching-off practices; it is also common for people to forget to do things like laundry in time and then end up using the tumble dryer.

Individual Agency

> *"I suppose sometimes you just feel like powerless – that you could do your bit and you almost feel like it won't make any difference."* ***H01MA***

The role of the individual in addressing what are global problems and the potential impact of their actions on those problems were real concerns of many participants. There was often a sense that other people were not behaving responsibly or in an energy conscious manner and that any action taken by the individual, at the cost of considerable effort, was in effect meaningless compared the wasteful consumption of millions. This was expressed to varying degrees by most of the participants, often while acknowledging that they would make an effort regardless. In many senses it was a conflict between a rational ideological stance to behave pro-environmentally and normative awareness that most other people do not. This is compounded by the perception that big industry is a far bigger environmental culprit that the individual in a domestic setting.

Lack of Information

> *"I suppose the interesting thing we don't know is what it costs us to have an individual device on. I put some chips in the oven, which we know from our meter takes up a lot… Are those chips really, really expensive?"* ***H01MA***

One of the greatest barriers to RECBs was a lack of concrete and credible information about energy consumption and environmental impact. The sample were, in general, probably more environmentally aware than average, however they were still confused about many different specific aspects of energy use. This seriously inhibited many from taking positive action and it provided an excuse not to make changes.

The most pressing concern in this area was what was the actual amount of energy (and thus financial cost) attributable to different appliances at different settings. In addition there was a desire to be able to make comparisons between different appliances or settings.

4.4.5 Energy Reduction Interventions: Future Interventions Desired

Participants raised a number of issues regarding what they would need to make energy consumption relevant and what they would like to see incorporated into future energy interventions. These ranged from technical specifications to meaning making to desired government policies. These are fascinating in many respects and many are highly relevant to future design work, but equally none should be followed blindly without future design evaluation.

Meaning Making

> *"Yeah, I think we'd all need to understand what the objective of doing it … what was the reward almost, especially with the girls"* ***H37MA***.

It was felt that future interventions should be able to clearly express the objective in making behavioural changes, and that information alone would not be sufficient to motivate change. This refers to the how and the why of RECBs and is crucial to the engagement of users.

Itemised Costs and Energy Consumption Break Downs

> *"if that was made simple so you could look at your dishwasher manual and say "Right, these are the five programmes. This is how much they use.... This is how much it costs me to put my dishwasher on," even something as simple as that I'm sure would make a big difference."* **H18FA**

There was widespread interest in being able to see what a given appliance was going to cost and how much energy would be used. Participants were particularly keen to able to compare what each setting would cost them so as to be able to make an informed decision on how to reduce consumption.

Realistic Reductions

> *" At least. But I think, you know, a lot of the major decisions seem unavoidable, but there must be other sort of more discreet things that we could be doing that would make a difference. I think that's what we're interested to know."* **H18FA**

One of the key resources desires in future interventions was the provision of realistic and attainable reductions. This is particularly relevant when occupants are already trying to minimise their use and don't necessarily see further opportunities for reductions.

Appropriate Situated Feedback

> *"I always thought it'd be good to have a gadget by the front door that tells you when you've left things on. You know, like people always worry that they've left their hair straighteners on, for example, and that sort of thing."* **H08MA**

As shown previously feedback devices often have limited effects because they are situated outside of the energy consuming activity and don't offer satisfactory alternatives to it.

One participant got to the nub of this by proposing a feedback device by the door which would alert you when energy was being needlessly used as you left.

Remote Control and Smart Controllers

> *"It was very cold when we came back on Sunday. I want them to invent that kind of, you know, phone your heating."* ***H42MA***

Several of the smartphone owners amongst the participants had grasped how the broad range of capabilities of their phones (i.e. wireless connectivity, geo-location, portability) could be harnessed as a feedback portal and smart remote control for many energy consuming appliances. Given the predicted rise in smart phone ownership, this seems to be a viable option which negates the need for a separate expensive display device.

4.4.6 Routinized and Constrained Behaviour

The mapping activity outlined in section 3.6.1 produced a different form of data to the transcriptions generated from the group interviews. It created a set of *routine maps* which illustrated in time and space the myriad activities performed by the participants on an "average" weekday and weekend. These maps, and the audio recordings of the participants describing their actions as they created them, provided a rich source of stories which conveyed *"how people understand and misunderstand things, events and places"* (Sanders & Dandavate 1999). This activity falls into the category of participant generated "Make tools" (ibid) which help uncover the tacit and latent aspects of peoples' actions and emotions and build empathy with their lives. Suri (2003) defines empathy as *"our intuitive ability to identify with other people's inner states based upon observation of their outward expressions."* As illustrated in figure 4-1, Sanders and Dandavate (1999) state that "make" tools go deeper than interviews ("say") or observation ("do") in uncovering the core of what we do and why.

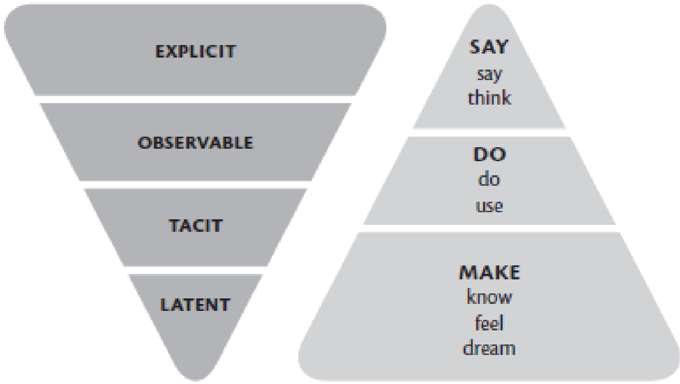


Figure 4-1. Saunders and Dandavate's (1999) Say -Do-Make model for experience Design (from Koskinen 2003).

The routine maps provided deep insight into the lives of the participating families, lives that were very different in nature to that to the researcher. The findings have had a profound influence on the overall research study, contextualising and verifying many theoretical constructs in the domain of busy domestic life. The maps show occupant behaviour occurring in space and time, and give a real sense of dynamic family life. They also gave a sense of how different family members and generations act individually and together in different ways. Some of the key themes to come out of the mapping activities are outlined below.

Domestic Life is Routine

Even though the participants were asked to map out an 'average' week day and weekend day, it became clear that the activities they discussed were performed routinely in reality. After completing the activity many of the participants expressed surprise, and in some cases dismay, at how routine and habitual their daily activities were. This is interesting for two reasons; firstly because it indicates a level of validity in the activity in terms of giving an accurate depiction of the types and nature of behaviours performed in the home, and secondly, because it illustrates the deeply routinized nature of many domestic activities.

> *"I'm just flabbergasted at how predictable we are! I mean, we practically do the same things every day!" H05MA*

There are large events which provide a macro structure to most families' weeks, e.g. work, school, sport, hobbies etc. and determine the rhythm of occupancy. At the micro level most participants talked about detailed regular routines around getting up, going to the bathroom, showering, having breakfast etc. These recollections were detailed and the activities were generally performed every day with the same macro structure.

Across all the participants, it became clear that the majority of their energy consuming activities were highly routinized in nature. They were performed often and in the same way and were often unquestioned by the participants while they were doing them. The mapping exercise, shown in Figure 4-2, caused many of the participants to examine their routine behaviours for the first time, allowing them to unlock the tacit and latent feelings and beliefs behind them. In this sense, the activity was extremely illuminating for all parties concerned.

Figure 4-2. The process of mapping routines.

Occupancy Patterns

One aspect of the highly routinized behaviours expressed by the participants was the way in which people used spaces within the home. It was not uncommon for many participants to only use their bedroom for sleep, or to only use the living room for set periods in the evening or at weekends. Places like bathrooms and the kitchen tended to be used throughout the day dynamically by all family members but in some cases people had rooms which they never or rarely used at all. Figure 4-3 below shows all the daily activity mapped for a weekday by the beta pilot house, and illustrates how household activity is concentrated in some areas and not in others. While this may seem self-evident, it highlights some key areas in terms of energy consumption.

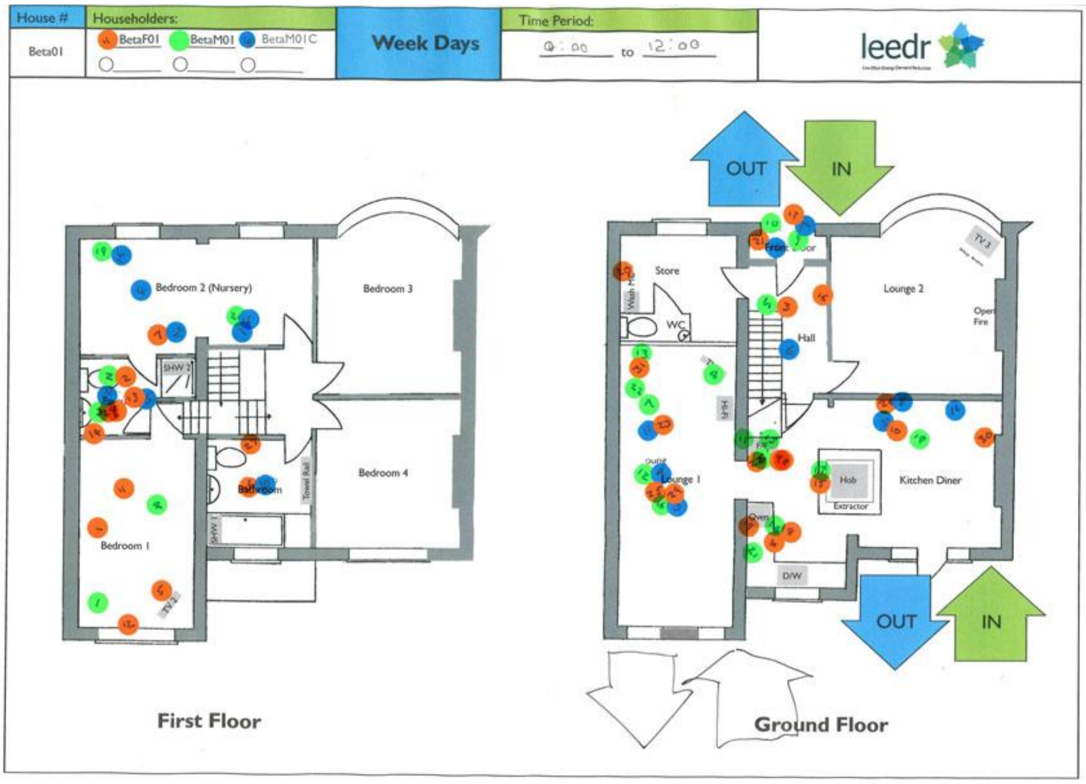


Figure 4-3. Beta house Compound Weekday activity map.

Many of the rooms which were rarely occupied or only used for fixed periods during the day, were heated to the same schedule as the rest of the home. This reflects the single zonal nature of most central heating systems amongst the sample, but indicates a considerable amount of energy being wasted. A more responsive heating system which better mapped to the actual routines of the household, could generate significant savings in this respect.

The inverse implication of these under-utilised rooms was the emergence of high occupancy ‘energy hot spots’. Rooms like the kitchen and bathroom were heavily used in all of the households and furthermore were used in energy intensive ways. This has a two-fold implication in the context of this research. Firstly, that these areas could be targeted for further investigation to gain more understanding about the nature of the energy consuming activities occurring within. Secondly, that they present themselves as being important locations for DfSB intervention.

Constrained and Pressured Behaviours

One aspect of these busy family routines which was notable was the constrained and pressured nature of many energy consuming activities. Driven by the needs of their families, it was very common for parents (particularly mothers in this sample) to perform a large number of energy consuming behaviours very rapidly in a short amount of time on a regular basis. They had developed housekeeping routines which fitted around the children's school life and their own work commitments. It was not unusual to hear people speak of doing "a quick tour around the house" after breakfast to collect and sort clothes, put on washes, clean the bathroom, tidy the kitchen and empty the dishwasher, all in quick succession.

These moments of high activity were entirely routine and unremarkable for those performing them, but illustrate a very important dynamic relating to energy consuming behaviours. It seems impossible that the participants could make reflective rational decisions about how much energy they were consuming when their attention was shared amongst so many tasks. Their actions were constrained by their situation, i.e. the amount of time they had to perform these necessary chores while also going out to work. It seems likely that the majority of these behaviours required little cognitive effort and were highly automatic in nature.

4.5 Conclusions

The findings of the User Study paint a picture of domestic energy consumption as being complex, multifaceted, dynamic and evolving. This in itself is a useful definition of the situation as it reminds us that it cannot be summed up in a parsimonious sense. However some consistent strands have emerged across the case study which provided novel direction to the intervention design process. These have been drawn into a new intervention selection model (see section 5.3) which has been used to guide the design phase.

4.5.1 Linking the Study to the Theory

The User Study has provided a wealth of information on a broad range of issues which contribute to energy consuming behaviours in the home. What is presented in this thesis is only a selection of the findings drawn from a larger thematic analysis (Appendix F), yet even this is lengthy in nature. In order to link these findings to theoretical underpinnings of this research study, it is necessary to seek commonalities between both. As goal framing theory (Lindenberg & Steg 2007) was selected as the lens to view behaviour through (see section 2.7), the findings of the User Study can be mapped to this.

Barboulos' (2012) investigation into the high order goals of goal framing and the sub goal frames which comprise them provides illumination on how to best classify the findings of the user study. By breaking the goals into more easily identified sub goals, see Table 4-1, the researcher can more easily draw comparison between generated findings and the theoretical construct underlining the research.

Table 4-1. The three high-order goals in goal-framing theory and seven related sub-goals (Barboulos 2012)

Goal Frame	Sub Goal	Motive
Gain	Value for money	To get value for money, pay a reasonable price, avoid wasting money
Gain	Quality	To get something of high quality and reliability, meeting one's highest expectations
Gain and Hedonic	Safety	To feel safe, calm and prepared for the unforeseen
Hedonic	Stimulation	To get something exciting, stimulating or unique, avoiding dullness
Hedonic	Convenience	To get something pleasant and comfortable, avoiding hassle and discomfort
Normative	Social Acceptance	To make a good impression, identifying with peers, conforming to expectations
Normative	Ethics	To act according to moral principles and obligations, avoiding guilt

Viewed though this lens, the findings of the User Study can be separated and classified into the three higher goal frames. In addition, other factors which emerged from the literature review and were drawn into a conceptual model (see section 2.7) have provided other classes in which to position the findings. This classification is detailed in Table 4-2 below. It is important to note that this matrix is far from exhaustive but indicates a commonality between a selection of the findings of the User Study and the theoretical framework derived from the literature.

Table 4-2. Matrix of the findings of the User Study as elements of the conceptual model.

	Drivers of Energy Consuming Behaviour (ECBs)	**Drivers of Reduced Energy Consumption Behaviours (RECBs)**	**Barriers to RECB (Inversely related to Goal frame)**
Hedonic Goal Frame	Comfort		Aesthetics of Low Energy Technologies.
	Convenience	Efficient Design	Comfort Baseline
			Lack of Information
Gain Goal Frame	Cost	Cost	Convenience Baseline
	Time		Confusing Information and Tariff Complexity
Normative Goal Frame	Children's Health	Environmental Concern	Individual Agency
	Social Norms		
Physical and Social Context	Multiple Occupants		Conflicting Occupant Behaviour
	Parenting and Children		Contextual Barriers
Personal Attributes	Theories of How Things Work	Upbringing	
Situational Behaviour			Forgetfulness

4.5.2 The dual nature of domestic energy use behaviours

The analysis of the interviews presents a picture of domestic ECBs being subject to a myriad of temporally and situationally changing drivers and barriers. It shows a group of participants who almost universally claim to want to reduce the amount of energy they use, but who often feel bound into the tasks that use that same energy. For example, most of the participants who regularly use the tumble dryer were aware it was a heavy consumer but often felt they had no option but to use it, given the time and contextual constraints around the behaviour.

The interviews have shown that there is a clear division between the different types of behaviour and decision making related to reducing energy consumption. The reflective "rational" decision to reduce energy consumption does occur, but relatively infrequently and often prompted by bills. However, there are a large number of factors which often inhibit such RECBs from occurring. By far the greatest of these is the disconnection between making the decision to reduce energy use and preforming the multitude of behaviours which actually consume energy. This disconnect is not just of time and frequency, but it is also of the relevant motivational goal frames driving both types of behaviours.

Each of the energy consuming behaviours is driven by a particular goal and level of context-driven automaticity. In trying to accomplish these tasks, the individual in the domestic setting will often as not be pressed for both time and cognitive resources and will proceed in the manner which achieves the goal while requiring the least of both. There is little space for mindfulness or concerted pedagogical reasoning in the time frame allotted to the task, nor does the domestic context necessarily provide any prompts to alternative lower energy means of achieving the task.

This is where the importance and value of contextual change driving environmentally beneficial behaviour shines through. '*Changing situational conditions is a promising way of modifying behaviour'* (Klöckner & Blöbaum 2010). By changing the immediate context of the behaviour, a new form of interaction is forced. This new form of interaction can be designed to lead the individual towards the most environmentally beneficial outcome possible in the given situation.

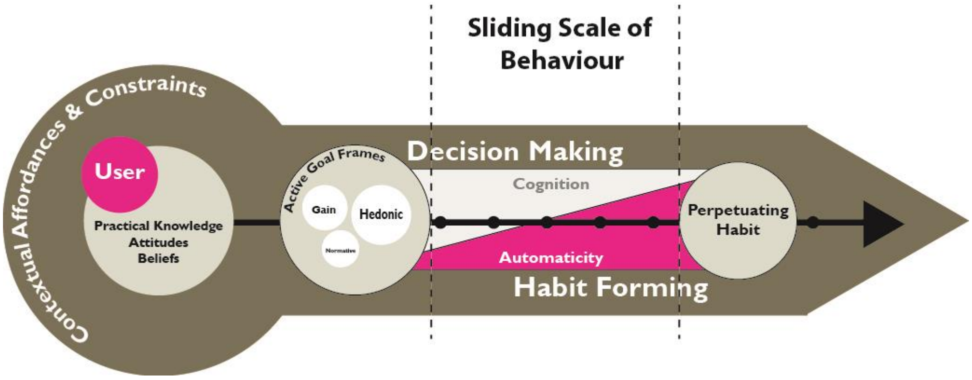


Figure 4-4. Refinement of Conceptual Lens.

These findings have led to the refinement of the conceptual model presented in section 2.7, it appears more promising to focus on determining the nature of the behaviour in question, be it reflective or situational, and target the intervention appropriately. As can be seen in Figure 4-4, the framework already allows for these two levels of behaviour, but their definition needs some modification. Chapter 5 provides an overview of the theoretical development stemming from this key finding.

5. Behavioural Intervention Selection Axis

5.1 Introduction

This chapter discusses the completion of the following two research objectives.

4. To test the role of the conceptual model through the analysis of the qualitative contextual study.
5. To develop a reliable Design for Sustainable Behaviour intervention selection axis.

This chapter outlines the development of two new theoretical constructs in response to the findings of the Literature Review and the User Study. They were developed sequentially; the conceptual model was a response to the Literature Review and in turn shaped the approach to the User study, and the findings of the User study gave rise to the development of the Behavioural Intervention Selection Model. They are, however, presented together in this chapter for the purpose of clarity as they have both been employed and referenced through the thesis and are considered instrumental in answering the large aim of the research.

5.2 Behavioural Intervention Selection Axis

5.2.1 Defining an Axis

The User Study (Chapter 4) provided useful insight into the complex situated nature of behaviour in the home which led to the creation of a new model of intervention selection for DfSB. The starting point for this model was the different types of energy related behaviour identified in the study. The two types of energy consumption behaviour (ECB) can be defined as:

1. Reflective behaviour

- Infrequent
- Cognitive
- Effortful
- Attitudinal
- Measured

2. Situational behaviour

- Responsive
- Context driven
- Automatic
- Minimum cognition
- Frequent

These two types of behaviour do not exist in a binary sense but rather on a sliding scale as shown in Figure 5-3. As such elements of both are present in most energy consuming behaviours. However, the more situational behaviour is the more it is driven by context and situation, with perhaps very little mindfulness or cognition from the individual.

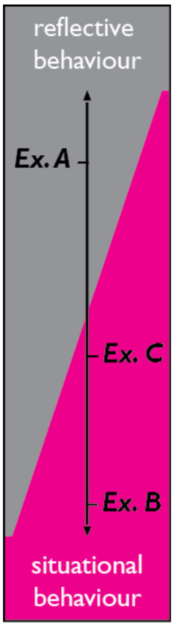


Figure 5-1. Sliding scale of ECB types.

Example A: "*After getting a large quarterly electricity bill I decide to reduce the amount of electricity we use at home.*"

Example B: "*I'm always turning the TV on and then leaving the room to go and do something.*"

Example C: "*I'm not that worried about leaving the doors open inside when the heat's on actually, because I think it probably it heats up the big landing upstairs.*"

5.2.2 Aligning intervention with behaviour type

The intervention approaches on the axis of influence (Lilley 2007) begin with information seeking to drive cognitive reflection and ends with design directing behaviour. In this sense the axis is well aligned with the sliding scale of reflective behaviour and can be combined with it to determine which intervention approach might be suitable for a particular behaviour (see Figure 5-4).

The more situational target behaviour, the more the intervention needs to direct the new behaviour through technological agency. This is simply because the target behaviour is not really consciously thought about, but is performed as a learned response to external stimuli. Thus it follows that the intervention must break the learned interaction by reconfiguring the user/product interaction.

It is important to note that a behaviour found to be reflective in nature can be successfully changed by an intervention strategy from lower down the axis. Similarly any behaviour on the scale should in theory be changed by an intervention strategy with more agency than one the behaviour may align to. However the inverse is not true, a more situational behaviour will not be successfully changed by an informational intervention strategy.

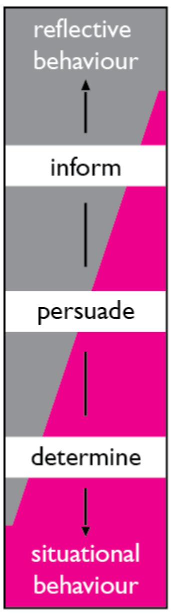


Figure 5-2. Behavioural Intervention Selection Axis

5.2.3 Auxiliary strategies to ensure compliance

An intervention can be successful in stopping a targeted behaviour by selecting the strategy appropriate to its level of reflectiveness or situationality. However, in order to ensure the new behaviour takes hold it may be necessary to also use intervention strategies which support the other aspects of behaviour forming, as in Figure 5-5.

For example, it may be possible to prevent water wastage through a smart tap which only pours when it detects hands, but the user may resent this imposition on their situated sink behaviours and seek a way around it. Here it becomes imperative that an auxiliary strategy of information and/or persuasion is used to reframe the problem and gain user motivation/understanding.

On the other hand, a highly reflective decision prompted by an informational intervention e.g. like deciding to reduce household energy consumption after a bill, needs to be transitioned into the situational activities which actually consume the energy. Thus a range of prompts and changes to the interaction may be needed at a situational level to ensure the behaviour.

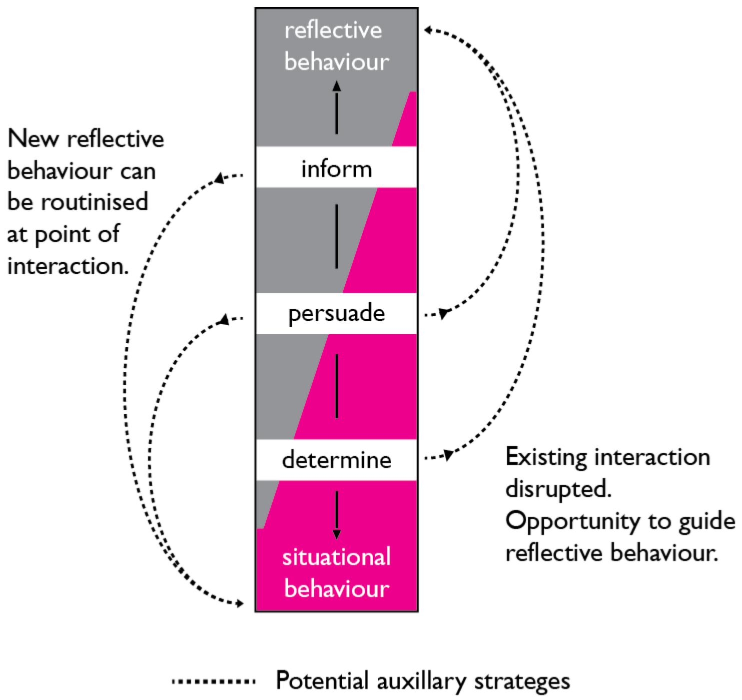


Figure 5-3. Auxiliary strategies to ensure compliance.

5.2.4 Required intervention obtrusiveness

There is a strong correlation suggested between the intervention approach chosen and the level of obtrusiveness required for it to succeed. Obtrusiveness can be defined as how much an intervention pushes itself forward into the users sphere of interaction (Zachrisson et al. 2011). The more embodied and situational the behaviour the more the intervention must prompt and tangibly direct the interaction towards the desired behaviour. To this extent obtrusiveness also deals with physical and temporal proximity to the interaction. However if a solution is purely technologically agentive, the necessary level of obtrusiveness will be lower as shown in Figure 5-6.

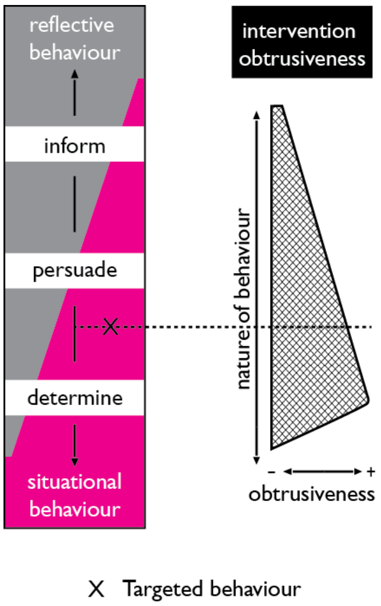


Figure 5-4. Required Intervention obtrusiveness.

Given the cognitive limitations and task saturation displayed in the interviews, the key concern for successful interventions is that they must be situationally and temporally relevant to the target behaviour. That is, they must be so obtrusive as to "intervene" in the context/behaviour paradigm at the time of action and in the sphere of the interface. Unless the intervention can react to the temporal embodied nature of the behaviour, it is unlikely to enter the active goal frame at that moment. Although one could just provide relevant information near the point of behaviour, e.g. a "switch me off" sticker beside the light switch, unless it can draw response from the individual at the time of action it is less likely to succeed. Thus in the example of the sticker on the light switch it can be said that the sticker is misplaced both situationally and temporally. Temporally in that the individual will only see it when they are switching the light on (this moment can be significantly disconnected from the moment when the light needs switching off). Situationally because if they haven't already gone to the light switch to turn it off they probably will not see it before they leave the room. In this case, a flashing alert activated by a motion sensor by the door would better instigate routinized behaviour change.

5.3 Conclusions

The Behavioural Intervention Selection Axis (BISA) outlined in this chapter seeks to address a recognised gap in DfSB theory; how we select which intervention strategy to use in a given situation. Building off published theory, and refined by findings from the User Study, the BISA redefines the types of behaviour to allow a more fluid interpretation by the designer. It expands the theoretically narrow definition of Habit to reflect real world behaviours which exhibit a similar reduced level of cognition, but which are driven by external situation factors.

The BISA proposes a broad and open intervention selection strategy, and acknowledges the need to use more than one strategy to target different aspects of a behaviour. It further incorporates the concept of obtrusiveness as a distinct and important variable in intervention approach.

Both theoretical constructs discussed here are used to frame and guide the research activities in the remaining chapters of this thesis, and in so doing are thoroughly evaluated for their validity and usefulness as tools to guide design.

6. Design Intervention Development

This chapter will outline the nature of the role of the researcher as designer in applying the findings of the literature review and the User Study to the design of DfSB interventions. Three intervention concepts were created and one was selected for further development. This will document the fulfilment of the following research objectives:

6. To concurrently test the Design for Sustainable Behaviour intervention selection axis suitability for use by designers.
7. To create a Design for Sustainable Behaviour driven prototype targeting reduced domestic energy consumption.

6.1 Design Methodology

6.1.1 Human Centred Design

The HCD process as defined by IDEO (2009) is divided into three phases; Hear, Create, Deliver (see Figure 6-1). The Hear phase is concerned with *"examining the needs, dreams, and behaviours"* (IDEO, 2009) of the people to be designed for and primarily utilises qualitative research methods.   The Hear phase is followed by the Create phase where the collected information is analysed and grouped allowing design themes to emerge. Through a process of synthesis, these are evolved into design prototypes which are fed back into a participatory design process. As well as offering opportunity for design refinement, this participatory design phase can be used to determine ethical issues such as the user's willingness to delegate control to the product (Midden et al., 2007). Thus refined, the designs are filtered through the Deliver phase which is concerned with balancing costs and capabilities to generate a feasible implementation plan (IDEO, 2009).

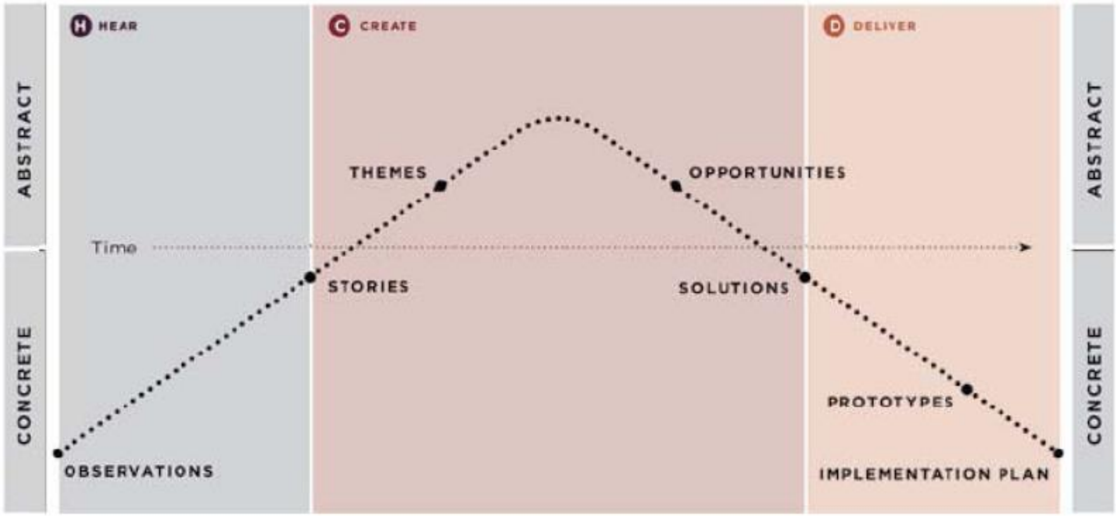


Figure 6-1. The HCD process(IDEO, 2009)

The field of DfSB has always espoused the value of following a user centred design approach (Lilley 2009; Wever et al. 2008; Wilson et al. 2013.) as a way of developing appropriate design interventions. Recently Wilson (2013) attempted to formalise this approach by embedding the aspects of DfSB in a recognised iterative UCD design approach, shown in Figure 6-2. This approach was based on the BS EN ISO 9241-210:2010 standard for Human-centred design for interactive systems (British Standards Institution, 2010). It outlines the factors necessary to account for in creating DfSB interventions and codifies them into a series of iterative activities.

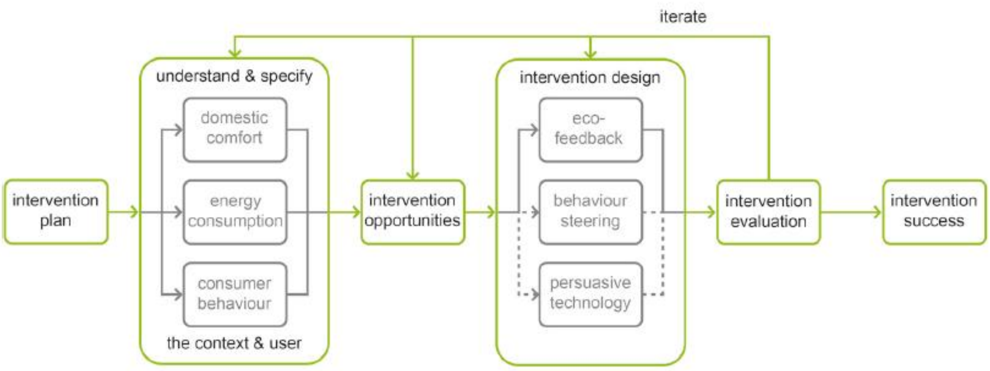


Figure 6-2. The Design Intervention Process (Wilson et al. 2013).

In the case of the research, the Literature Review (Chapter 2) and User Study have provided much of the basis for the first phase “understand and specify the context and the user”. The later stages of “intervention opportunities” and “intervention design” are detailed in this chapter, as is related research. The “intervention evaluation” is divided between this chapter, in form of pilot testing and iteration, and main evaluation in Chapter 8.

6.1.2 Design for Sustainable Behaviour

The criteria for the design can summarised by Figure 6-3 below, this reflects gaps identified in the literature relating to the need for a DfSB interventions to actually generate a significant reduction in energy consumption over a medium-to-long term study. Answering this gap in DfSB research practice is a central goal of the design process, and by extension of the subsequent evaluation process. To achieve this any design generated will have to enable an alternative behaviour to that targeted. This alternative behaviour will have to incorporate a defined reduction in the amount of energy used comparable to the existing behaviour, this is termed an energy gain. The change in behaviour and energy consumption must be measurable by both quantitative and qualitative means. Finally, any such design must be technically feasible and achievable within the scope of this research.

This final criterion is perhaps the most important in terms of the intervention design because unless fully functioning robust prototypes can be developed to test in the context of use for a significant period of time these critical gaps in DfSB knowledge will remain unanswered. It is also the most limiting factor, as the resources available for the intervention development are extremely small compared to those required for most innovative new product development. As a result, all the concepts developed have had to acknowledge the technological and formal limitations that are inherent to these boundaries. This means that the designs draw heavily on off the shelf componentry which is reflected in the aesthetic qualities they display.

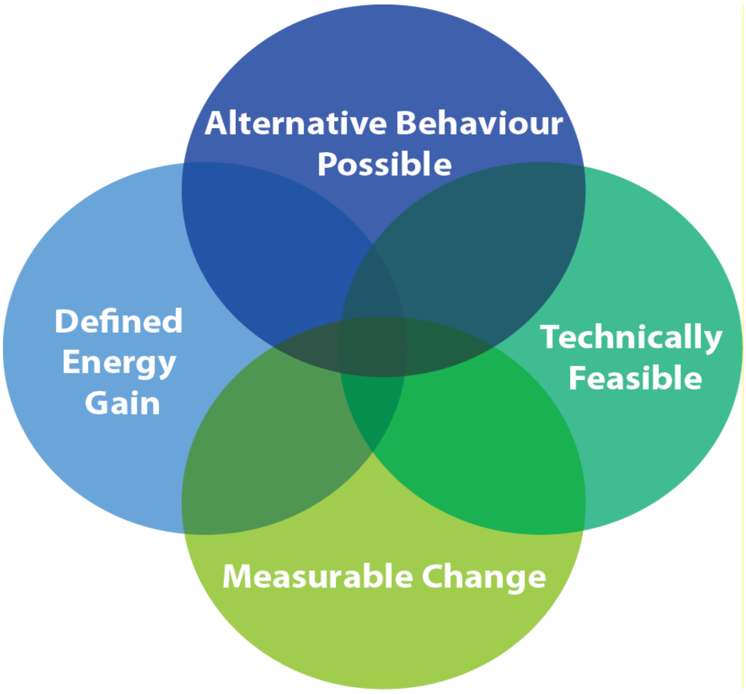


Figure 6-3. The Four Criteria for DfSB intervention design.

The Conceptual model and Behaviour Intervention Selection Axis

The design intervention development was used to evaluate the success of the conceptual model and Behaviour Intervention Selection Axis (BISA) as tools to guide design. The intentional and contextual aspects of the relevant behaviours are primarily drawn from the User Study. These are mapped against the conceptual model and BISA to frame the design problem. The axis is used to suggest the strategies needed to address the different forms of behaviour, with the additional concepts of auxiliary strategies and obtrusiveness drawn upon where applicable.

The BISA used in this chapter is a later iteration to the one developed in Chapter 5. It has the same core, but takes in learnings from subsequent testing and development (see Chapter 8) which highlighted the need to make functionality matching (as per Wever et al. 2008) an explicit part of the axis, see Figure 6-4 below. Functionality matching had always been considered as part of the design process and had been inherent in generating the concepts, but had not been overtly recognised in the BISA at that time. It is included here to formally illustrate its application in the design process.

Rather than illustrating and describing the designer's full immersive understanding of the broader contextual and intentional aspects of each of the targeted behaviours and their relevancy to the conceptual framework, one key variable will be illustrated alongside the BISA in this chapter. This variable is the active goal frame as described by goal framing theory, and is included to provide insight into the intentionality of the behaviour as expressed by a number of participants.

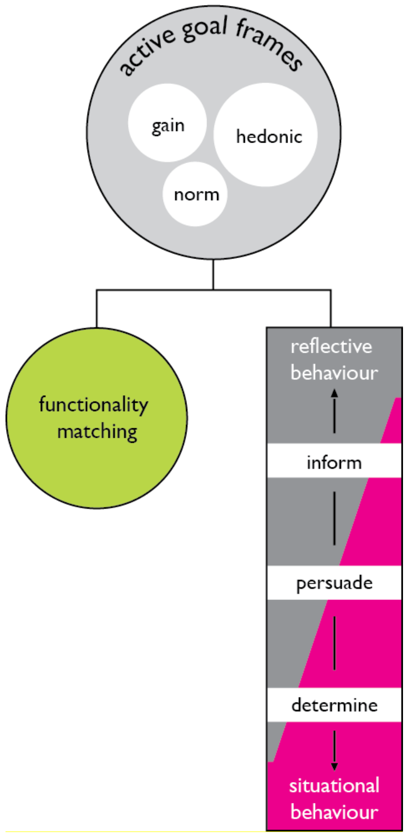


Figure 6-4. BISA including active goal frames.

6.2 Concept 1 – Heat Me: Comfort behaviours in a broader context

6.2.1 The Problem Space

Quantitative Energy Basis

Without a doubt heating is by far the largest single consumer of energy in UK homes, estimated to have been 62% for the year 2013 (Palmer & Cooper 2014). Moreover it has been rising, not only in total quantity but also as a proportion of the total domestic energy use, as shown in Figure 6-5 below.

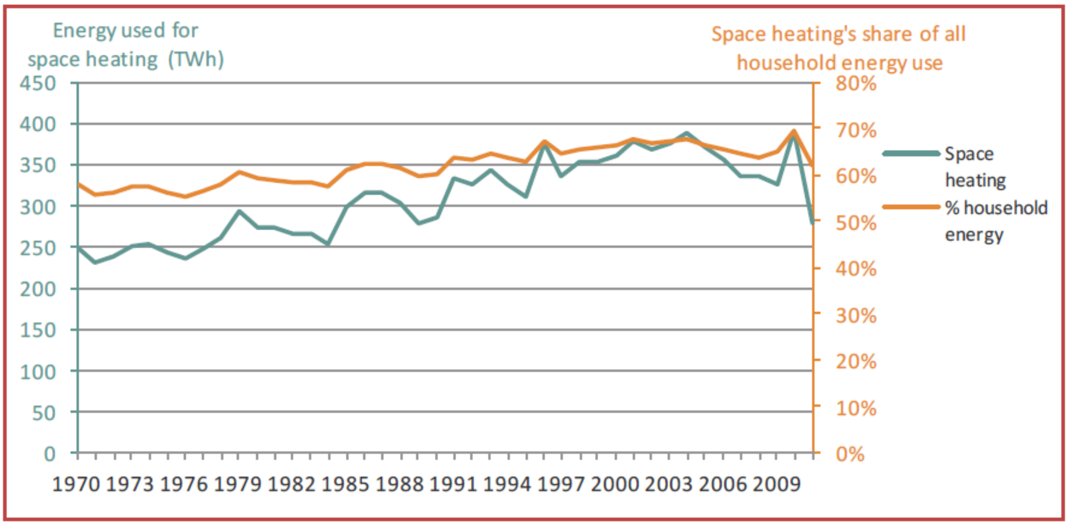


Figure 6-5. Household energy use for space heating (Palmer & Cooper 2014).

There are many possible reasons for this, including larger living spaces and heated areas, but one reason has been the general increase of average indoor temperatures over the last 40 years (see Figure 6-6).

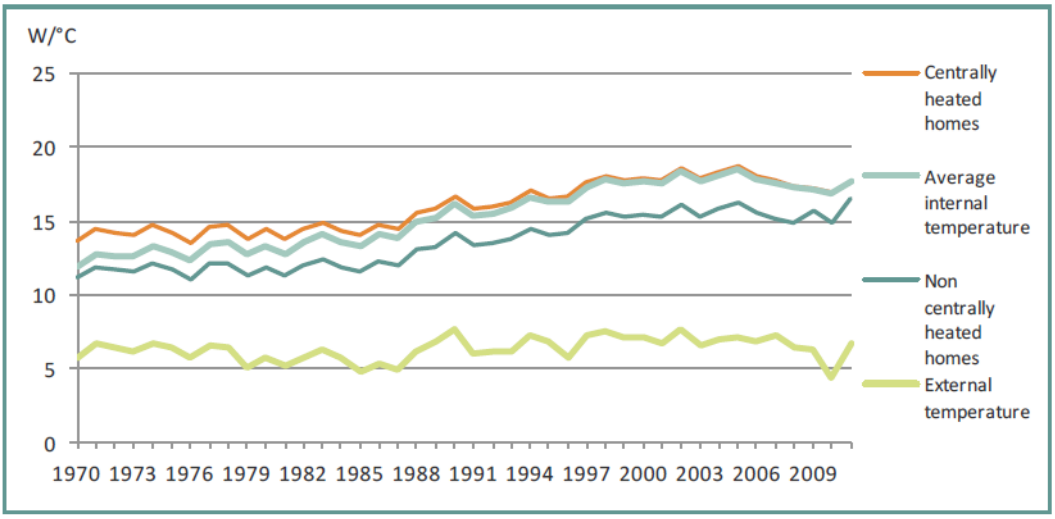


Figure 6-6. Average UK winter internal and external temperatures (Palmer & Cooper 2014).

Heating behaviours have been shown to be the result of a complex socio-techno inter-relationship (Chappells & Shove 2005), and there are many factors which determine the actual heating related energy consumption of a given household. One Scandinavian study has found there to be a difference of a factor of four between the energy consumption related to heating amongst different households (Gram Hansen 2010).

User Study Insights

What follows below is an analysis of some of the findings of the User Study relating to space heating behaviours. This will be used to give insight into some of the reported heating-related behaviours, and also to illuminate the intentional aspects of these behaviours.

Heating as a Basic Need

Given the UK's temperate climate and the ubiquity of central heating amongst the participating households, it was considered a given that some level of space heating was a basic requirement.

> *"Well, I'm sure everyone would rather have the heating on than sitting in the freezing cold just because it's there. I mean you'd like to think you're saving the polar bears and what not by sitting with the*

> *heating off, but if the heating's there you're going to turn it on."* **H01FAc1**

> *" No, but it does come to that point when it's really cold in the morning when you get out of bed. You want at least the chill to be gone, don't you?"* **H01MA**

Comfort

Going beyond the basic requirement for some heating in the home, the importance of heating towards making the home a comfortable place was mentioned by many of the participants. As shown in the analysis of the Users Study, comfort was a strong motivational factor in many energy consuming behaviours (ECBs).

> *"I suppose when you're talking about home it's like being able to have lighting, the heating, being comfortable in our home."* **H10FA**

However, in terms of being comfortable not all participants equated this with high usage of the central heating. Many preferred to use elements of personal heating equipment, such as warm clothes, blankets, hot-water bottles etc. However, these alone were not considered sufficient and central heating would also be used.

> *"It depends how cold I feel. I mean I don't really like the dry air that central heating produces, so I try to put a jumper on and stuff like that, but there's just some days where that's just not cosy enough. So it's kind of a cosy factor thing."* **H30FA**

Cost

Cost was spoken of as the primary motivation for reducing energy consumption by almost all participants. For many this led to a vigilance in their usage of heating, and indicates that an intervention which aided them in reducing the amount spent on energy would be successful.

> *"We think very carefully about putting the heating on, which is partly for sustainability, but it's also partly the cost as well. We're rather skin-flint."* ***H39FA***

> *"Definitely having spent years in my life with not lots of money and saving money and conserving heat and various other things it's actually, I think, really important."* ***H45FA***

However, statements such as the above speak towards a reflective motivational state and these could not be expected to remain dominant in response to the very situational nature of experiencing cold. As much was indicated by one participant who illustrates a motivational hierarchy very common amongst many of the sample; comfort first, cost second.

> *"So I wouldn't think we're necessarily flagrantly burning money, but we're not… We're aware of what's going on, but we're not going to be uncomfortable about it unless the energy bills keep going up astronomically."* ***H10MA***

Multiple Occupancy

While the different physiological and psychological needs of multiple occupants has an impact on the energy consumption of any household, this is particularly impactful in relation to heating. Due to the nature of most central heating systems, if one person desires or requires heating, the entire house gets heated.

> *"Because you're out at school, dad's out at work and if I'm in Manchester, then the heating's off for the day, whereas if I'm here, then the heating's on for the day. So it's definitely I think."* ***H08FA***
> *"And we heat the whole house, don't we?"* ***H08MA***
> *"Yeah, for me to work in the office."* ***H08FA***

> *"I mean you've asked for the heating on tonight and I'm boiling hot and you're freezing cold."* ***H05FA***

The impact of this behaviour is difficult to address without the installation of automated zonal control, however this is an expensive and invasive technological fix and would not be suitable for the purposes of this intervention. A more fruitful area of investigation is related to the different temperature setting preferences expressed by different occupants. Several participants described themselves or their family members as being warm-blooded or cold-blooded. This meant that in several families there were 'thermostat wars' where different family members would change the thermostat setting for the whole house based on their preference. Often as not, this resulted in the temperature being turned up from the bill-payers preferred setting.

> *"I'm always coming downstairs and finding that someone's turned the blooming thermostat up to 22 or 23! I keep it at 17 you see, that's enough."* **H41MA**

It seems fair that different family members should be able to receive extra heat and higher settings at the time that they need them. However, the static nature of thermostatic controls means that the setting remains at a higher level until an interested party checks it again. It seems likely that this could result in the heating being set at a higher than intended temperature for long periods of time.

Health

A number of participants spoke of the effect that having children had on their heating behaviours. This appears to have been driven by information provided for them by the NHS when they had young children.

> *"Was that a concern for you when you had the boys, to get that thermometer in there to keep it constant?" I*
> *"Only when they were babies because a baby's temperature is supposed to be theoretically 20 and below."* **H10MA**

> *"And I think also last winter because it was so bad we actually had several nights where we had the*

heating on all the time, even overnight. If it was just the two of us we would never have done that, but because Louis' room is just so cold we had to keep it on." **H38FA**

The concern for the health and wellbeing of one's children is an extremely powerful motivation for parents. It potentially provides an opportunity for an intervention to frame lower heat settings as being beneficial for the health of one's children.

Responsive Control

While nearly all of the participants used their heating programmer to some extent, many were aware of its limitations. The programmers used allowed for the setting of fixed on and off times for the heating, in some cases allowing for different settings for the weekends to work days. However, unless the participants schedule was absolutely fixed, there were times when their settings did not reflect their actual needs.

"Yeah, very recently. So yeah, but it was very cold when we came back on Sunday. I want them to invent that kind of, you know, phone your heating. They have invented it, but…" **H42MA**

"But for instance if I were out and Lorraine was at work and she wasn't coming back until late, the heating would still come on at 4 o'clock or whatever which it needn't do. If you could walk out of the house and say I'm out… If the heating system control understood people and what they were doing and where they were and you could clock in and out, then it could probably more intelligently work out whether it should be on or not at a certain time whereas it's a very, very simple heating control." **H40MA**

The degree of control possible through the programmers is generally quite limited, and a richer interface would allow a greater degree of responsive control. Such an interface could be embedded in a technology commonly used in many households, such as a smart phone or tablet.

Summary

The key areas highlighted by the research study can be summarised as follows:

- Internal temperatures are rising.
- People get used to a certain level of heat
- There are times when people just want more warmth.
- Different occupants have different heating needs.
- Thermostats get turned up and left there.
- People use personal heating.
- Parents start new heating practices when they have kids.
- There is a strong desire for smart phone control of heating system.

The motivation to create comfort is a powerful behaviour-shaping force which must be addressed in any design intervention. However this does not mean maintaining the status quo, instead less energy intensive ways of maintaining comfort must be found. These must be dynamic and adjustable to match the changing needs of participants, and to achieve this without significant changes to the fabric of the house it is likely that they must be more responsive to the actual proximity to the occupants.

6.2.2 Behavioural Intervention Axis: Heating Behaviours

The User Study findings point towards heating behaviours being mainly driven by a hedonic goal frame; comfort, somewhat mitigated by a gain goal frame; cost. However there was also cases where parents had pushed aside put those active goal frames in an effort to do what they "*ought*" (Lindenberg & Steg 2013) to for their children's health; a normative goal frame. These motivational goal frames bring three key elements to the fore that the design must address design. They are far from a complete set of motivations, but they provide a solid point of departure. There are number of other potential motivational goal frames, contextual factors, and personal attributes to allow for. These provide both the boundaries and the opportunities for design.

These goal frames are what is behind the participant's heating behaviours, they do not constitute behaviours in themselves. It is how these antecedents are expressed in the form of various behaviours that is the target of the DfSB intervention. These behaviours are the interfacing of the user and designed technology, e.g. a digital programmer, a window, or a blanket. A range of the most prominent recorded behaviours has been placed on the behavioural intervention selection axis, see Figure 6-7 below. This indicates the types of intervention strategies which may be suitable to address them. The diagram also represents the key elements required in terms of functionality matching, and the active goal frames.

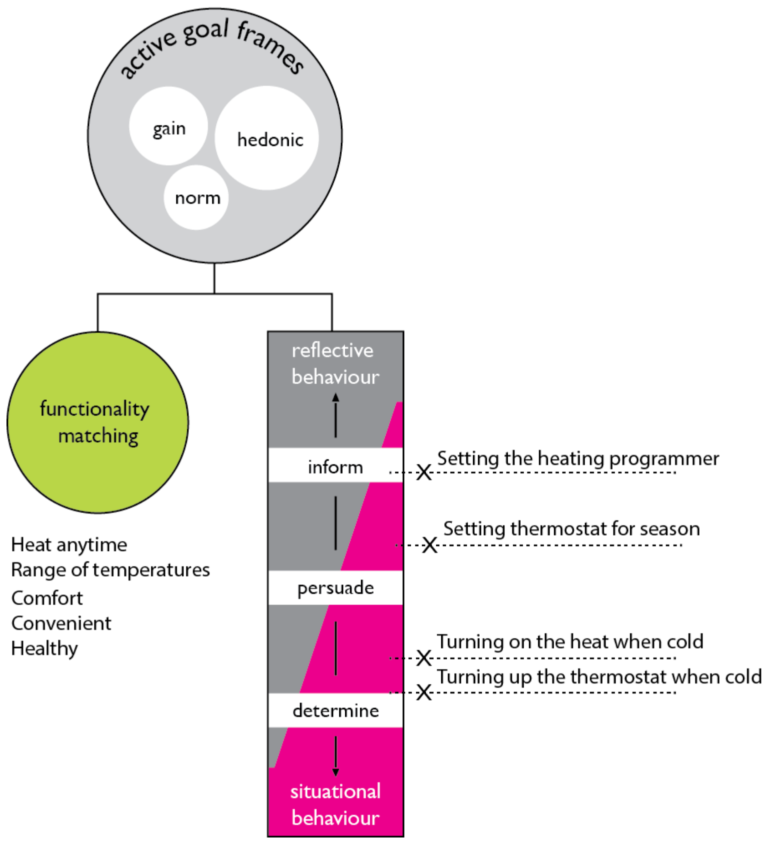


Figure 6-7. Illustration of the motivational and behavioural aspects of heating practices.

6.2.3 Concept design

Warm home is the name given to the heating intervention. The name and colours used throughout are a subtle form of persuasive framing. The intervention works across the digital/physical divide, employing both a digital heating control interface and situated physical elements of personal heating. The existing programmers and thermostats in the house are replaced by Wi-Fi enabled dumb units; the app becomes the central point of interaction for controlling space heating. The design of this intervention is in part influenced by the author's MSc dissertation (Hanratty, 2009) but is substantially different in most areas.

Figure 6-8. Warm Home system showing 'dumb' wall-mounted unit and digital control interface.

The key behaviours to be changed are a mixture of reflective and situational behaviours (see Figure 6-7). In dealing with the reflective behaviours, there are two elements: setting the heating programmer for the season and setting the thermostat for the season. The design did not go into detail with regards to setting the heat programmer. It was felt that this was an area best determined by individual household routines. Setting the thermostat was chosen as the main target of a reflective intervention approach. It is estimated that reducing the thermostat setting by 1 degree can save 310kg – 360kg carbon dioxide emissions a year (Energy Saving Trust, 2015).

Taking inspiration from the normative goal frames expressed by some parents, the design positions a lower temperature setting (18° C) as being the healthiest choice for the family. This setting is made the default, and is supported with persuasive text at the point of control as shown in Figure 6-9.

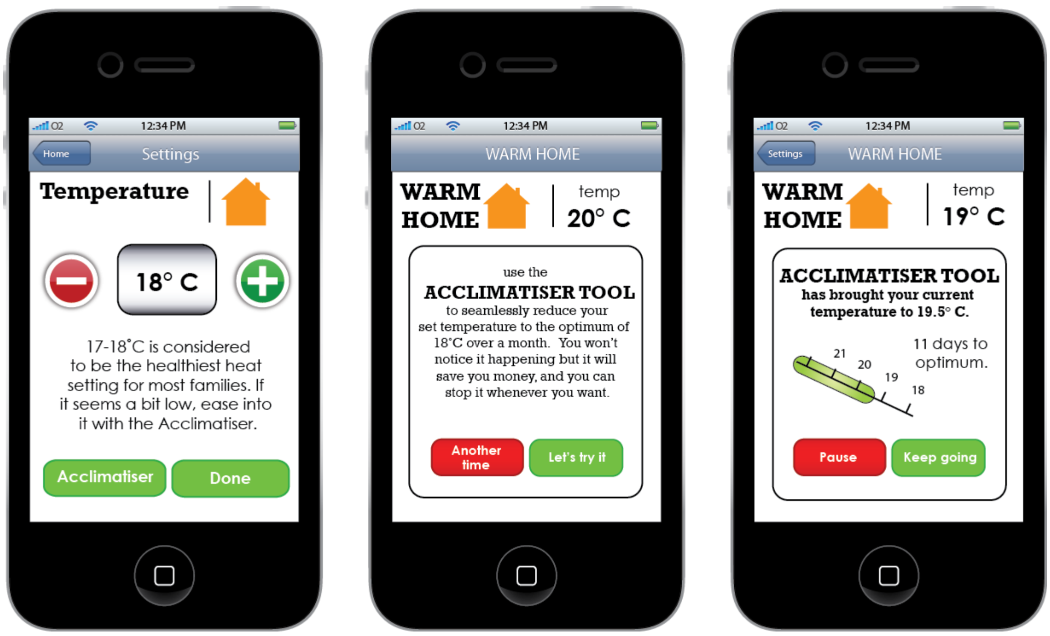


Figure 6-9. Temperature setting and Acclimatiser screen flow.

The design approach has tried to balance addressing the reflective aspects of reducing thermostat settings for the season through persuasion, with a sensitivity to the strong situational response that a sharp drop in temperature would have, i.e. the user turning the setting back up again. This potential situational response is targeted in the Acclimatiser feature which aims to get occupants to lower their set temperatures to 18˚ C (64˚ F). Acclimatiser is based on a key insight that automating the temperature reduction to take place over an extended period, at a rate of less than 1˚ C a week, could remove the user's wariness of being shocked by a cold house.

The main aim of the intervention is lowering and maintaining the set temperature. To this end it is geared to allowing the users to have moments of high thermal comfort whenever they desire them, it does so through both digital and physical means. Digitally, it builds in friction to the adjustment of the baseline temperature settings but makes the selection of heat "boosts" very easy; these can just be extra half hour periods of heating at the set temperature (i.e. 18˚C), or periods of raised temperature (i.e. 21˚). This allows for the normal variance in individual preference to be expressed without the long term impact related to static thermostats.

Figure 6-10. Boost screen flows with Heat Me prompts.

It is in the physical elements of the design that the situational behaviours are most fully addressed. The intervention is supplied with a number of "*heat me*" bags (Figure 6-11); heat retaining pouches filled with soft blankets that affix to the radiators in the home. These offer a trade-off between the "worthy" cooler settings and the physical pleasure of warm cosy blankets and clothes (and anything else participants might fill them with). They enable the cold blooded family members to have a warm comforting experience, one they can integrate into their existing practices. The design is clearly influenced by personal heating practices such as the use of blankets and pyjamas, but these have been given form and agency as an intervention approach. Crucially the pouch is to be placed in areas of highly sedentary activity, such as the sitting room. It is while people are at their least active that they require higher ambient temperature to compensate for the lack of heat generated through exercise. As the pouches retain the heat, the blankets etc. contained within would still be warm long after the heating was turned off. It was hoped this would encourage users to seek the instant comfort and pleasure of reaching for a warm blanket, rather than turning on the heating and having to wait. This situational behaviour was supported by a persuasive strategy in the screen flows, see Figure 6-10.

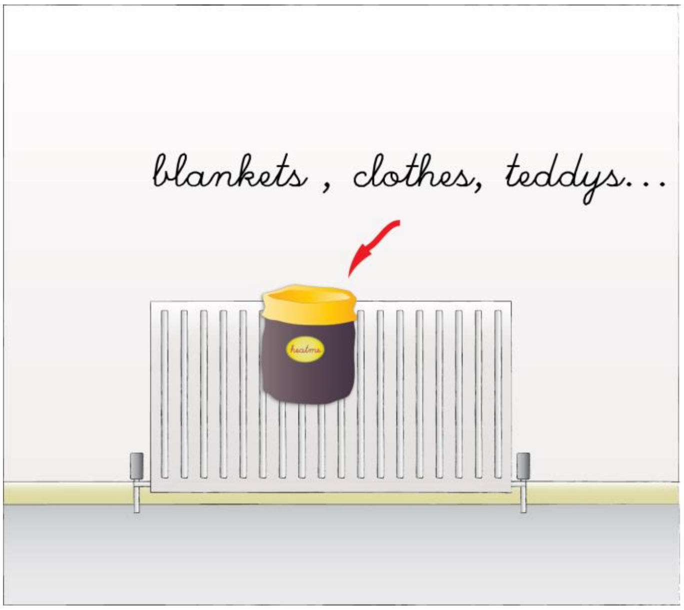


Figure 6-11. *Heatme* heat retaining pouches attach magnetically to the radiators to heat blankets etc., for sedentary comfort.

The design would allow for a quantitative measurement of energy use by recording the heating activity remotely. Both the duration and frequency of heating periods could be logged, as could the relevant thermostat settings. This would show both the nature of programmed and boost use, but would also show participant engagement with temperature setting reductions. These could be extrapolated to find quantitative energy use data, which would show the real impacts and nature of any use. Furthermore, qualitative techniques could be used to ascertain the level of use and engagement with the non-digital aspects of the design, as well as participants' engagement with the system as a whole.

6.3. Concept 2 – AirDry: Building Better Laundry Habits

6.3.1 The Problem Space

Quantitative Energy Basis

Laundry drying is an area of increasing energy consumption in the UK. Whereas historically clothes would have been dried outdoors or indoors on a clothes horse, changing patterns of cleanliness and work have led to a large increase in the frequency of clothes washing and the use of energy-consuming tumble dryers (Shove 2002). A recent comprehensive report on energy consumption in the UK, Powering the Nation (Owen 2006), has shown that, in houses with a dryer, 80% of clothes washes are followed by powered clothes drying. It also measured the energy consumption related to clothes dryers:

> *"The average annual consumption for clothes dryers, typically tumble dryers, was 394 kWh, and the average number of cycles was 260 a year. Such use leads to an average cost of around £55 per annum, or over £300 over a five year period."* (ibid)

What is particularly interesting is the fact that clothes drying has a much larger impact that clothes washing, even though both are obviously tied to each other. Table 6-1 below shows the relative energy consumption by demographic.

Table 6-1. Energy consumption related to Tumble Drying by sector (Owen 2006).

Household type	Washing machine use (kWh/yr)	Clothes dryers use (kWh/yr)	Total kWh/yr for households with washers and dryers
Single pensioner	144	344	488
Single non-pensioner	173	332	505
Multiple pensioner	111	287	398
Household with children	170	342	512
Multiple household with no dependents	178	497	675

User Study Insights

Though far from universal amongst the participants, tumble drying was recognised as being an energy intensive practice, but was deemed necessary by many due to the need to have clothes washed and dried quickly for external commitments. These included getting school and work clothes ready for the next day, sports gear turned around daily, and also a general time saving practice.

> *"I need to have his sports gear ready for tomorrow"* **H46FA**

> *"It drives me mad that the school has white shirts! I mean what were they thinking, young boys get them dirty in five minutes! And you have to do 60 degree wash or it just won't be white again, I've tried it trust me."* **H41FA**

While outdoor drying is considered very beneficial by the participants, and obviously has no energy consuming impact, they found the unpredictability of British weather to be a significant barrier to doing so. In most households both parents were working to some extent, which left no one at home during the day time to keep an eye on washing hanging outside.

> *"There are times when I put the tumble drier on and think "I shouldn't be doing this. I should hang it out on the washing line, but there's a chance of showers and I've got to go out and I need it dry, so I'm going to put it in the tumble drier."* ***H01FA***

As with all behaviours, convenience was an especially strong motivation for clothes drying. Not only was the tumble dryer, in many cases, located beside the washing machine, it also involves less handling of individual items of clothings than, say, hanging the clothes out on the line.

> *"I put the tumble dryer on all the time because it's convenient and because I'm willing to spend the money on the tumble dryer because I've got a clean load that I don't really need to iron, but they're dry and I can pull them out. Yeah, I'm aware it uses a lot of electricity and it's not environmentally very sound, but I want dry clothes and I want to be able to fold them up and put them away. So yeah, I'm aware of it, but I don't alter massively. No, not massively."* ***H43FA***

Tumble drying has a 3 fold time and labour saving, in that it requires less effort to just bundle clothes into the dry then hang them up on the line, it can be done independently of weather and day light, and it also saves time on ironing.

> *"Saves time on ironing"* ***H23FA***
> *"I refuse to iron, I hate it"* ***H05FA***

Like any routinised behaviour, using tumble dryer was rarely questioned in practice with it having become an automatic response to the washing machine being finished.

> *"I have to retrain hubby here who just sticks the clothes in the dryer without thinking"* ***H45FA***

In this sense it is for many people a fully situational behaviour; automatic, frequent, context driven, with minimal cognition.

Quick reliable, weather independent drying is intrinsic to many people's daily lives. Prevalent standards of hygiene and cleanliness dictate that many people feel they can only wear a garment a single time before it must be washed, and by extension dried. To achieve this people, particularly working singles and families, need to be able to dry clothes quickly, reliably and, in many cases, at night. This "lock-in lifestyle" (Bhamra et al. 2008) makes outdoor drying a challenging proposition to introduce, it requires a level of planning rarely evinced or possible in the busy families of the participants, and even then it is unreliable as the weather is subject to constant change. Another factor is people's obvious financial inability or unwillingness to purchase enough clothes to allow for a whole week of wearing each item once them before washing at the weekend. This is particularly true of school and work uniforms and sports gear, functional garments which are often quite expensive.

6.3.2 Behavioural Intervention Axis: Clothes Drying Behaviours

The User Study shows that for many people, clothes driers provide a quick reliable and especially convenient way of drying clothes. This convenience links strongly to the hedonic goal frame and is a very strong motivational factor to account for. As drying clothes is inextricably linked to the washing of clothes, the normative factors around cleanliness have a role to play. Participants were aware of the cost implication of tumble drying, but this was largely overruled by the hedonic aspects relating to convenience. It is obvious that a quick, reliable, and weather independent drying solution which consumes less energy is needed. In addition such a solution would have to be convenient to use, and to dry clothes in such a way that they do not require extra processing, and especially, extra ironing.

As shown by the literature (Owen 2006), and also by the participants themselves, in many cases tumble drying follows clothes washing in every instance. This frequency of repetition combined with the proximal nature of both appliances, makes using the tumble dryer a highly automatic behaviour for many people.

There are also some elements of reflective behaviour regarding drying outdoors. However for an intervention to successfully encourage people to use this low-energy method the unreliability of the weather must be accounted for in any design. These behavioural factors are illustrated in Figure 6-12 below.

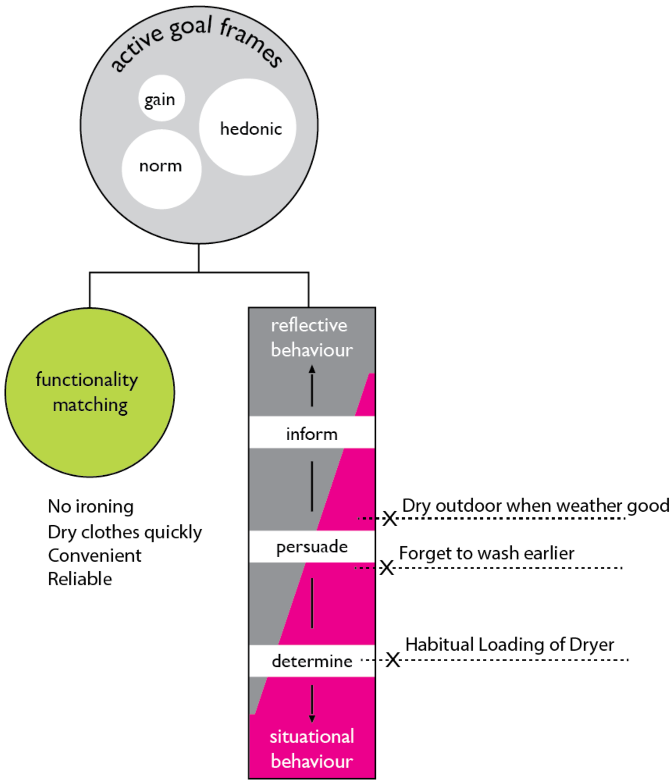


Figure 6-12. Illustration of the motivational and behavioural aspects of drying clothes.

As a largely situational behaviour, tumble drying can only be addressed through a highly agentive design intervention, one requiring a considerable degree of contextual change. Following the Behaviour Intervention Selection Axis (Figure 6-13), this type of intervention which dramatically changes the interaction would be more effective if supported by goal aligned informational and persuasive strategies.

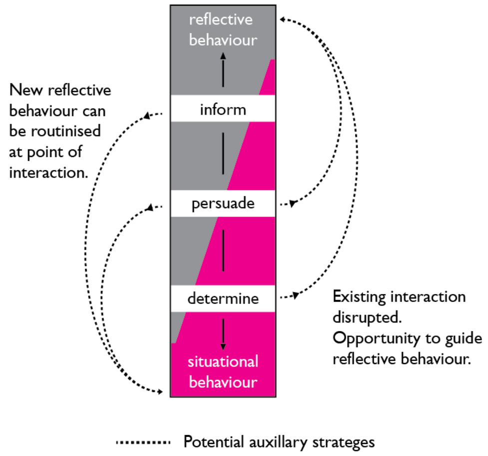


Figure 6-13. Behavioural Intervention Axis.

6.3.3 Concept Design

In seeking to create a novel design intervention within the criteria outlined in Section 6.3.2, research was done into alternative drying technologies which could meet the requirements of the Design Specification. Cold dehumidification was found to be a low energy technology being used by some members of the public to dry their clothes. The system requires a way of hanging clothes in an enclosed space, where a dehumidifier can circulate air and extract the moisture. Drying times were reported to be around 1-3 hours for a standard load (DIY Wiki 2014). Importantly, this system was reported not to create creases in the way that drying on radiators does, which would allow users to not have to iron.

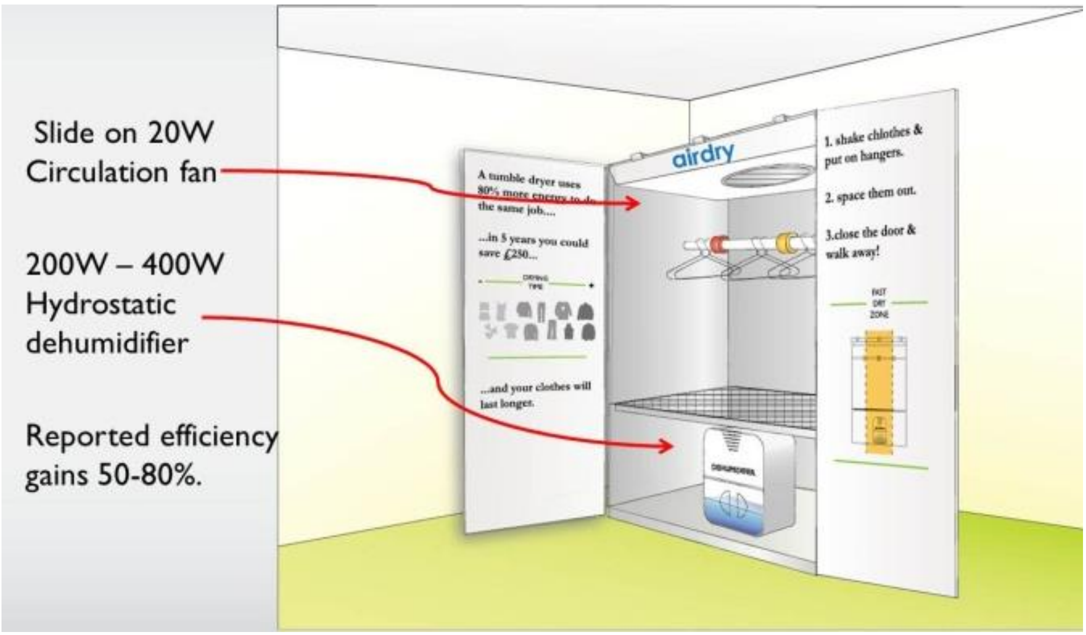


Figure 6-14. AirDry unit.

It was found that the efficiency of the dehumidifier system could be markedly increased by the addition of a fan to circulate air within the enclosed space. Thus a unit was designed to house one which would easily attach to the top of an existing wardrobe (see Figure 6-14). It is worth noting that such a fan would consume between 5-20 watts of electricity while in use, and even combined with the 200-400 watts a dehumidifier would consume while active this would be considerably less than the average tumble dryer at 1000 watts. Two large graphic panels were designed to be attached to the doors to convey this information to the user while also providing clear and simple instructions on using the device (Figure 6-15). These instructions focussed on showing users how they could achieve quick and reliable drying through proper use of the unit. They also highlighted the area of the unit which would provide the most rapid drying, if they needed an item of clothing dried for work for example.

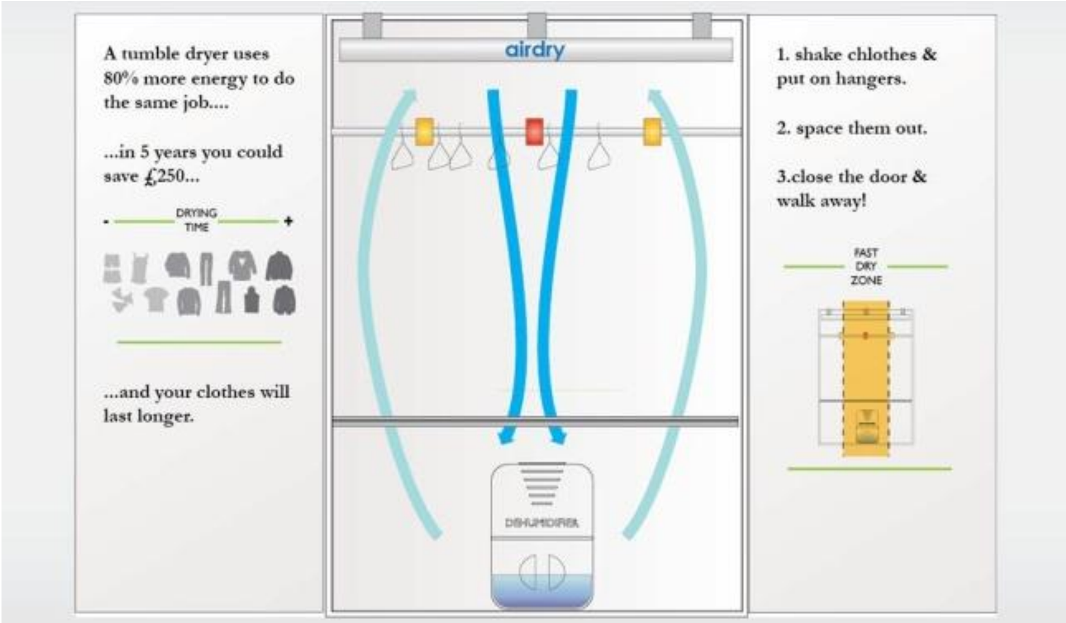


Figure 6-15. Diagram showing enhanced air circulation from fan and printed informational panels.

While this technical system appeared promising as a means of matching the required functionality, it is however an entirely new drying practice, with a high degree of contextual and behavioural change. This degree of change is necessary to disrupt a highly situational behaviour but it requires persuasive support to drive uptake and regular use. As such, it was decided to support the intervention with a digital application which could be used to persuasively frame information and guide reflective decisions at the right point in the behaviour.

Key to being able to prompt users at the correct points in behaviour was the integration of off-the-shelf energy-monitoring technology. The chosen form of these was AlertMe smart plugs, which would be connected to both the washing machine and the dehumidifier in the AirDry unit (see Figure 6-16). These smart plugs would allow monitoring of the energy consumed by both the units, but would also enable a digital application to prompt the users when both devices were finished their use cycles.

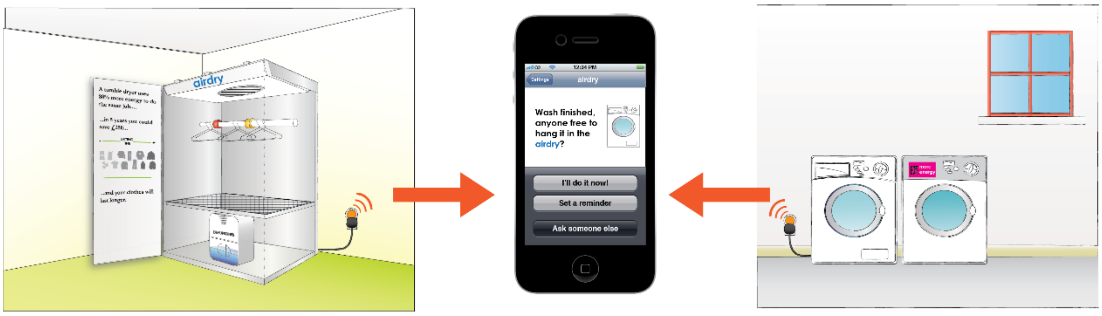


Figure 6-16. AirDry energy monitor network.

Being able to tell when the washing machine was finished (via the sustained drop in energy consumption), would allow an application to prompt the user to use the AirDry system while also informing them that the clothes were washed. This would automatically place a reflective prompt in front of the user and hopefully break the unquestioned habit of transferring the clothes from the washing machine into the tumble dryer. The application could also leverage the abilities of the smart phone platform it was being run on and provide the user with a number of options (see Figure 6-17 below). One of these was 'Remind Me Later', which allowed the user to set a prompt to return at a time when they felt they would be at home. The other option sought to use the existing family network and to automatically send a message to another family member asking them to take the clothes out and put them in the AirDry. These features would hopefully be considered convenient and pleasurable to use, and would both facilitate the uptake of this new behaviour by the wider family at large while also engendering a hedonic motivation to use the intervention.

Figure 6-17. Automatic prompts that: wash is finished, clothes are dry, water reservoir needs emptying.

In the same vein, automatic prompts were also created to let users know when the hydrostat in the dehumidifier signalled that the clothes were dry, and also when the water reservoir was full and needed emptying. These prompts were specifically targeted at establishing the reliability of the intervention as a means of drying clothes. As a means of re-framing the potential inconvenience of having to empty the water reservoir, it was intended that the participants would be given a house plant as part of the intervention package. This plant could be watered with the contents of the reservoir turning what could have been seen as a task into a pleasurable (hedonic) experience (see Figure 6-18).

Figure 6-18. AirDry companion plant.

Figure 6-19. Dry weather alert screen.

The digital application was also used to support environmentally positive behaviours such as drying clothes outside without the use of any energy at all. A dry weather alert, Figure 6-19, would be linked to weather service to prompt users to do a wash and hang it outside when an extended spell of clear weather was forecast. Other reflective prompts also in the digital application included energy consumption data, laundry reduction tips, and improved use suggestions,

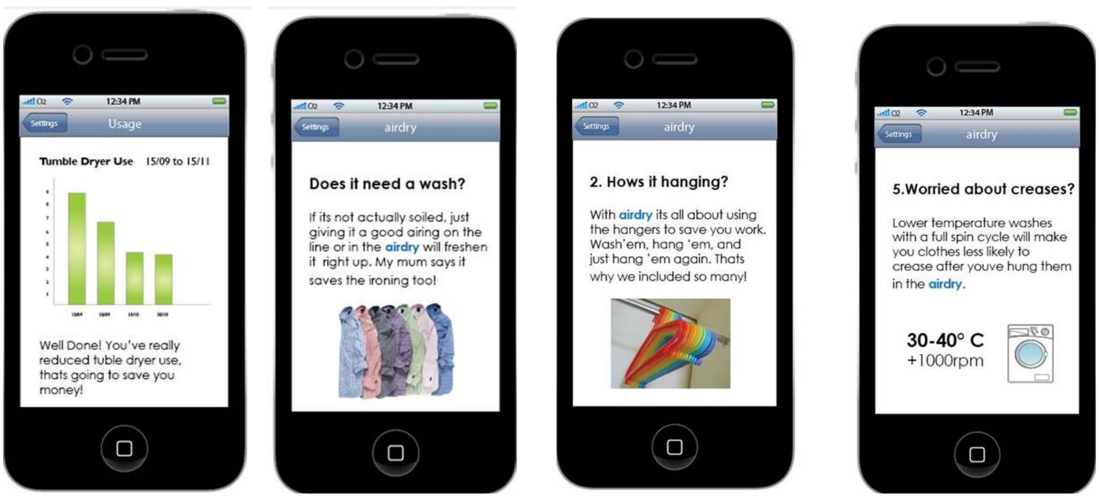


Figure 6-20. AirDry energy consumption, laundry reduction, and use suggestions.

In terms of evaluation of the intervention, the AlertMe smart plugs would provide information on washer, tumble dryer, and **airdry** use allowing for quantitative evaluation of consumption. This could be compared to the baseline monitoring data being collected by LEEDR to ascertain the impact of the intervention of tumble dryer use and resultant energy consumption. Use metrics from the digital application would provide insight on use of the digital platform and features. Further qualitative understanding could be gained from conducting interviews with participants after the intervention period.

6.4 Concept 3 – Enuf: Reducing Shower Duration

6.4.1 The Problem Space

Quantitative Energy Basis

Hot water use is estimated to account for around 17% of the average UK family's energy consumption (Palmer & Cooper 2014). One of the major users of hot water in the home are bathing and showering practices. There has been a significant increase in the proportion of houses with showers over the last forty years (Walker 2009b), and an corresponding increase in the number of people who routinely shower instead of bathing.

Over this period, the technology used to provide hot water has changed from predominantly hot water storage systems (i.e. hot water cylinder) with finite storage capacities, to continuous water heating systems (i.e. combi-boilers) with a potentially infinite capacity to deliver hot water (Walker 2009a). In parallel and perhaps inextricably linked to this, bathing practices and norms have changed considerably. People now shower more than bathe, shower for longer and routinely use cosmetics and hygiene products designed to encourage daily use (Hand et al. 2003). Seen like this, current showering practices can be seen to be a reflection of a wider socio-technical system. Within this trend there is of course considerable variation between individuals and households (Morley & Hazas 2011) Consideration of the broader system aside, the net result of this is an increase in shower frequency and duration, leading to an increase in related energy and water consumption.

> *Identifying the drivers of behaviour may in turn help to underpin a discussion of the most effective means of achieving behavioural change in personal washing, in particular individuals reducing the duration of showers (Walker 2009b).*

Recent quantitative investigations backup this trend, showing an increase in the duration of showering times. A 2011 study by Unilever (Unilever 2011) used data loggers to monitor the shower in over 300 UK homes, and record the duration of showering times. They found the average time to be 8 minutes, which is a significant increase over the previously assumed 5 minute average. Furthermore, they found that showering was using almost as much energy and water as bathing.

> *An eight minute shower with an average water flow rate uses around 62 litres of hot water (compared to 80 litres for a bath) and costs around 30p. That's a total of 90,000 litres per year for the average four-person family, at a collective cost of £416. (Unilever 2011)*

The impact of shower type and water flow was extremely pronounced, with the average power shower from their sample consuming over twice as much hot water in the same duration. This would equate to the same amount of water as the average bath in 5 minutes, and an annual running cost for the typical family of £918. Individual variation in showering times is also extremely pronounced, with the average shower duration around 12 minutes for teenage girls.

Though the sample size of the Unilever study is small, and has not been reviewed for publication in academic journals, it derived its findings from actual measurements recorded in real participants' homes. This gives it a level of credibility in comparison to much shower consumption data, which is derived from energy modelling (Walker 2009a) or self-reporting of times (e.g. Energy SavingTrust 2013).

It seems that showering times of 12 minutes are well beyond the theoretical minimum (Elias et al. 2009) needed to complete washing and grooming practices, and could be reduced through persuasive intervention. Whether or not the other motivations beyond cleanliness which give rise to these longer times can be addressed through these means is dependent on the nature of the intervention itself.

User Study Insights

Though the User Study has uncovered a range of motivations behind energy consuming behaviours such as comfort and convenience (see section 4.4) which have a bearing on showering behaviours, they did not have an explicit focus on showering itself. The routine mapping exercise showed that the majority of participants showered most days of the week, and at regular times. Only a small number of adult participants had baths more often than showers and most young children were washed in the bath.

Due to the lack of investigation undertaken into showering behaviours during the User Study, research gathered by LEEDR colleagues Kerstin Leder-Mackley and Roxana Morosanu from the Department of Social Studies, Loughborough University was used to explore the behavioural domain. This research was part of a sensory ethnography (Pink et al. 2013) of 11 of the participant households under taken as video tours (Pink 2007) of bathroom practices where family members recounted their routines in context. The materials shared took the forms of video clips and of summary notes compiled by Kerstin Leder-Mackley which can be found in Appendix H. Though originally grounded in a different theoretical background, sensory ethnography, these materials were analysed by this author through the lens of the conceptual frame work.

Hygiene

Though not explicitly verbalised by the participants, it was apparent that it was taken for granted that the primary reason for showering was personal hygiene. The participants spoke of showering regularly and using cleaning products but only spoke particularly of having to get clean in relation to sports or exercise which may have caused them to get sweaty or muddy. However, all participants had a routine of cleaning involving soaps or shower gels and hair care products. The need behind these routines was rarely discussed, except in the case of some hair care routines where female participants in particular, often had set routinized behaviours.

> *"Apparently not everybody does two hair washes, but I didn't know that."* ***H39FA***

This motivation can be seen as a normative one, that is to maintain a socially acceptable level of hygiene, but it may also have hedonic aspects in terms of feeling good about oneself. This appears to be the reason why people shower, and also the reason guiding the frequency of their showering. It does not, however, seem to be the strongest factor in determining the length of their showers.

Pleasure

For many participants showering was more than a means of just getting clean. It was a pleasurable activity within itself. Contextually, we can see that some of the elements that make up the shower, such as flowing warm water and a private space, could be some strong enabling factors in this regard. This is borne out by many of the participants comments, who spoke of showering being a pleasure. In some cases this was spoken of in terms of comfort and warmth.

> *"It's not just about getting washed, it's just… a nice feeling to just be in the shower and get warm."* ***H01MA***

Getting warm in the shower is something most people could relate to, but by its very nature it requires a longer duration of showering to allow the body to heat up.

Others spoke of pleasurable aspects of showering in terms of pampering and self-care routines. These routines often involved the use of different products and body brushes, scrubs etc. and had an element of ritual to them. By their nature these rituals took a relatively fixed extended period to perform, again impacting the duration of the shower.

> *"I'm in for about a minute, H45FA's in for about ten minutes!"* **H45MA**
> *[laughs] "Well, yeah, I do, I like showering, so…"* **H45FA**
> *"Is that about right?"* **H45MA**
> *"Yeah, I do my hair and condition my hair, and wash my face."* **H45FA**

These are clearly very strong hedonic goal frames which reinforce longer showering durations. The tangible artefacts enabling this motivational goal frame are the flow of hot water and various body care products, two factors which will be difficult to address through the intervention.

Waking Up

Related to the pleasurable aspect of showering was the way a number of participants spoke of using the shower as a way to wake up. Showering was seen as a gentle way of entering the world for the day, where the flow of hot water was used to gently refresh the body and wake up.

> *"How long would you shower for?" Interviewer*
> *"About five minutes I'd say, longer if it's cold outside, or if it really early 'cos it's a way of waking up."* **H33FA**
>
> *"If I have to I can be in and out in two minutes, but in the morning it's so nice, and I just stand there and let it wake me up."* **H33FA**

It may be possible for an intervention to accelerate this waking up process through other means than standing under hot water for an extended period of time.

Daydreaming

The private nature of the shower makes it a warm and comfortable space for introspective thought and daydreaming.

> *"And are there things that you think about while you're in the shower?"* ***Interviewer***
> *"Yeah, I normally think about what I need to do to sort of get ready for the day. So if the children have done all of their homework or have everything that they need for school, and what I need to take into work, and how we're gonna get to school. […] Cos it tends to be my five minute thinking time in the morning, just to kind of get my head around everything and remember everything that I need to do for the day."* ***H42FA***

This does not necessarily mean that they were engaged in idle thought but rather that showering provided a time to reflect on other things going on in their lives or tasks they may need to do that day. While their thoughts are clearly reflective in nature, they are not to do with the act of cleaning themselves. Rather, they illustrate the deep situationality of showering. As a behaviour enacted everyday it displays a very high degree of automaticity driven by a warm comfortable context. This allows participants to focus their reflective efforts elsewhere with the apparent impact that they are spending longer in the shower than necessary.

Efficient Users

A sizable proportion of the participants, the vast majority of whom were male, did not see showering as a pleasurable experience to be savoured. For many people, showering was an almost purely functional task, and necessary in terms of maintaining hygiene. These participants spoke of showering as something they had to do, but something which they tried to minimise the amount of time they spent doing. This desire to reduce time was more often than not driven by the need to get to work quickly in the morning, and can be seen to be part of a gain-driven goal frame. That is that the less time spent in the shower, the more time available for productive work leading to the improvement of personal resources. This indicates that these participants might embrace something which allowed them to better keep track of their time and minimise the duration of their showers.

> *"I'm in and out sort of within five minutes top."* **H39MA**

> *"To be honest, the focus is on achieving the end of getting clean as fast as possible."* **H40MA**
>
> *"Would you think about anything, for the day or anything, when you have the shower or are you just waking up [laughs]?"* **Interviewer**
>
> *"At 4.30? [amused] Err, no... I tend to be like, erm, I'm literally just thinking I've got to get out of the door."* **H40MA**

> *"I'm very quick in the shower, very quick."* **H37MA**

> *"I just need to wash and get out, I don't stand in there enjoying it or anything like that. Water on. Just go in, turn it on, stand under it, wash, turn it off, get out."* **H05MA**

> *"No, nowhere near ten minutes. I wouldn't even say nearly five. Three minutes for me, I reckon, that's me done."* **H46MA**

These participants give an indication that where the motivation is to get out of the shower as quickly as possible, that sub 5 minute shower durations are totally achievable. However, the fact that most of the participants who expressed these opinions were male might suggest that these times may not be possible with the more complex grooming routines of females.

Long Shower Times for Younger Participants

An interesting trend across the sample was the regularity of which younger participants claimed to have longer showers. It was not uncommon for teenagers to speak of having

15-20 minute showers and not to express any feeling that this was in any way a wasteful behaviour. It seems that the facilitating technology of continuous water heaters has allowed younger people to shower for these durations without a sense of the implications in terms of resource use.

> *"H30fc2 takes about 20 mins I'd say."* **H30FA**
>
> *"If I want like a relaxing shower I don't wanna waste too much water, so I just have a shower that's enough to fill the bath, and then turn the shower off. Does that make any sense? ... So I sit under the shower in the bath while the bath goes up around me, and then I turn the shower off and the bath is full."* **H05fc2**
>
> *"How long would it normally take you?" Interviewer*
> *"Probably 10 to 15 minutes."* **H01mc2**
>
> *"It takes between 5 and 20 minutes depending on how ever long I want to be in there... and how awake I am. Also, if I'm really, really freezing cold, I would use the shower to warm up and I'd just stand there underneath the water."* **H01fc1**
>
> *"Sometimes we'll get together and just play games and things, so if it's the play games night, I do it like in five minutes. But if it's not [pauses] ten or twenty?! [smiling] But I like taking long showers. So if I want to get somewhere and it's good, I'll do it quick, if I want to."* **H40fc2**

The fact that many of these younger participants had previously expressed an awareness of environmental issues in the User Study interviews implies that they are not connecting their extended showering with having an environmental impact. This is linked to the deep situationality of showering, a behaviour users don't think much about while performing, but it also speaks towards a need to activate reflective thinking about the link to environmental matters.

Wasteful Behaviours

Aside from the amount of time participants chose to spend standing in the shower under a flow of hot water, there were also examples where warm water was wasted without being used. One apparent issue was participants turning on the shower and engaging in another task while waiting for the water to warm up.

> *"It takes a few minutes to settle down, it's not the right temperature straight away, so I think what people do is they go in the bath and switch the shower on, then get ready to go in the shower when it's settled to the right temperature."* ***H01MA***

While this behaviour makes perfect sense, in terms of not accidentally climbing into a stream of cold water, it seems very likely that in many cases the water has reached the appropriate temperature some time before the participant becomes aware. This would lead to a quantity of hot water being dumped straight down the drain, with the resultant resource waste. While it is unclear the scale of this waste, it seems likely, given the level of situationality expressed in relation to other aspects of showering, that it is worth investigating.

6.4.2 Behavioural Intervention Axis: Showering Behaviours

The motivational aspect of showering is multi-faceted, and perhaps can be best considered divided into different behaviours. The parent behaviour, that is to wash or to take a shower, seems to be driven by normative goal frames relating to perceived social standards of hygiene. However, while this drives the frequency of showering, it does not seem to be the major motivational factor behind the length of people's showers.

For many participants, this is driven by a hedonic goal frame originating in the comfort, pleasure and privacy that showering gives them. This hedonic motivation leads to longer showering than is functionally necessary, and is the largest challenge for an intervention to overcome. However it is not the sole determining factor in longer showering. For some participants there were many occasions when they were motivated to minimise the amount of time they spent showering. This was often driven by a desire to spend this time performing productive work, and can be seen as being driven by a gain goal frame. These factors, along with the specific behaviours they drive, are illustrated in Figure 6-21 below.

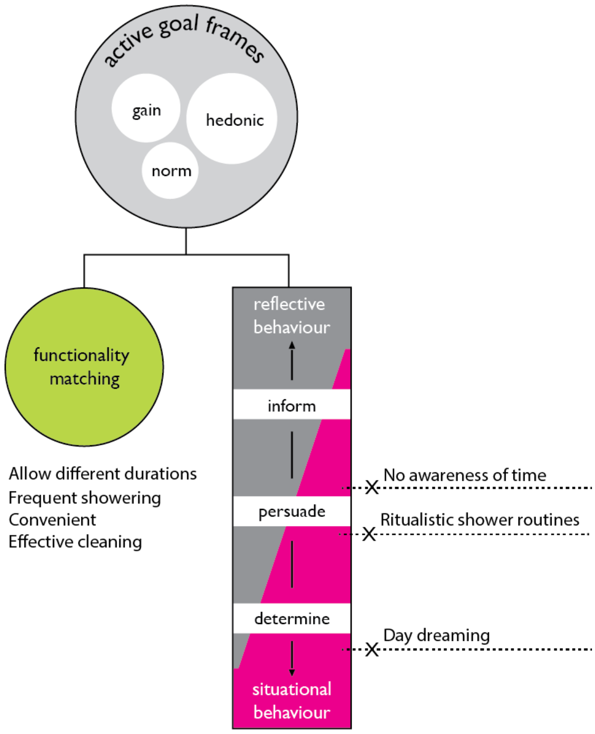


Figure 6-21. Illustration of the motivational and behavioural aspects of showering.

As an activity that is performed almost every day, the actual process of washing oneself is a deeply situational one. This means that it requires little reflective thought by the person and is performed semi-automatically. This leaves the person free to think reflectively about other things, like planning their day or conversations they had recently. There is a tendency for people to become preoccupied with these musings, and to cease to pay attention to the primary task of cleaning themselves. This leads to periods where people are just standing under a flow of hot water but not actively using it. There is a need for an intervention to disturb the situationality of this behaviour and to refocus the participants' reflective attention on the task of cleaning themselves efficiently. Such an intervention would need a high level of obtrusiveness to insert itself into the user's consciousness, see Figure 6-22.

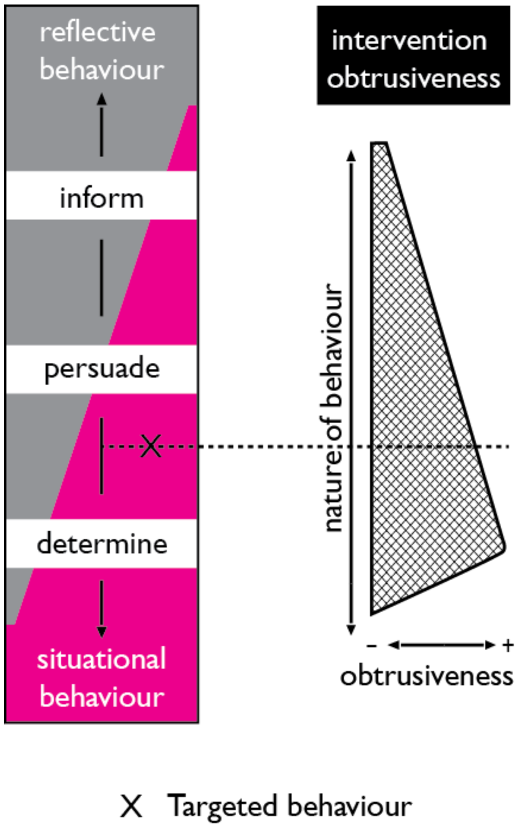


Figure 6-22. Required Intervention obtrusiveness.

For many participants cleaning themselves efficiently does not seem to feature as a motivation. There appears to be a disconnect between the participants' views about showering and their strongly expressed views about the cost of energy and their aversion to waste. It seems likely that an intervention would have to re-frame showering as having a financial and environmental impact, in order to create the motivation to shower more quickly. This would need to be realised in a compelling way to actually generate a change in behaviour.

For those users who are already motivated to minimise their time showering an intervention should enable and encourage them to keep their times short by allowing them to keep track of time and rewarding shorter times.

It is clear from the different routines spoken of by the participants that a wide range of showering routines existed. These varied greatly in length and purpose. In terms of functionality matching, it seems clear that any intervention which tries to reduce the duration of these showers must still allow users to determine how long they need to be in the shower for. A solution which forced the user to finish in a specific time would not function for everybody.

The intervention must also allow people to shower as frequently as they want as this is driven by external factors beyond its control. Taking into account the motivations expressed in the User Study interviews, the intervention must also be convenient to use and not significantly impact the comfort or effectiveness of the cleaning experienced by those showering.

6.4.3 Concept design

When reviewing the technical survey of the participants' houses, it became clear that there was a wide variety of shower types, hot water sources and bathroom fit-outs. This, combined with the perceived reluctance of project participants to have major plumbing work done, directed the intervention development towards a device that could be fitted to mediate consumption in an existing shower unit. This would make it a pathway 2 type intervention according to Renström et al (2012).

Such an intervention type cannot affect the degree of contextual change desirable when trying to change deeply situational behaviours. To achieve this it must display a high level of obtrusiveness, that is to say it needs to insert itself forcefully into the users consciousness. When this is done, there is an opportunity to activate different motivational frames to get the user to shorten the duration of their shower.

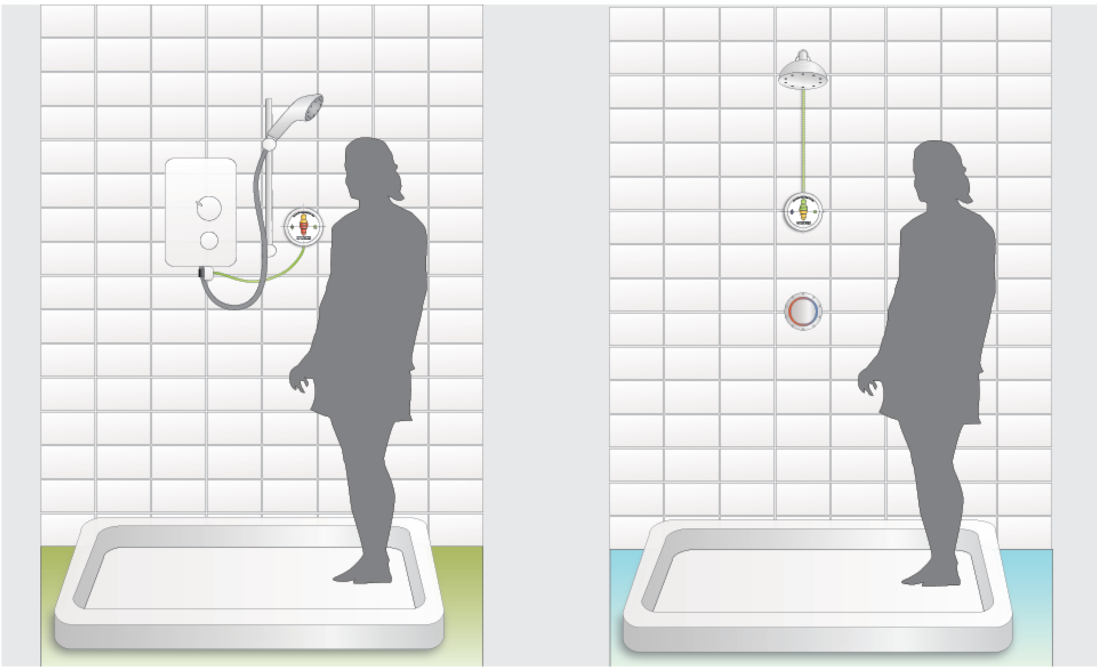


Figure 6-23. Enuf intervention in context.

The intervention concept, Enuf, is an automatic persuasive shower monitoring device, which is designed to attach to a range of shower types (see figure 6-23). While its primary function is to monitor shower activity, it has been designed to give a range of feedback and behavioural prompts to the user to encourage them to shower more quickly. Key to achieving this is the fact that the device is designed to turn itself on automatically and provide feedback without the user having to remember to do so. This addresses the situationality of showering behaviours, where it is unlikely that users would remember to turn on a new device while performing their routine behaviour. The device is not trying to get all users to shower in 3 minutes or less, it is however seeking to reduce the number of showers over 9 minutes duration by reframing them as being unacceptable. It recognises that for many people their personal care routines, involving shampoo, conditioner, body scrub etc., could not be completed in less than 4 or 5 minutes. If the majority of showers can be brought under 8 minutes, it is likely the resultant average would be considerably below that captured in the Unilever study (2011).

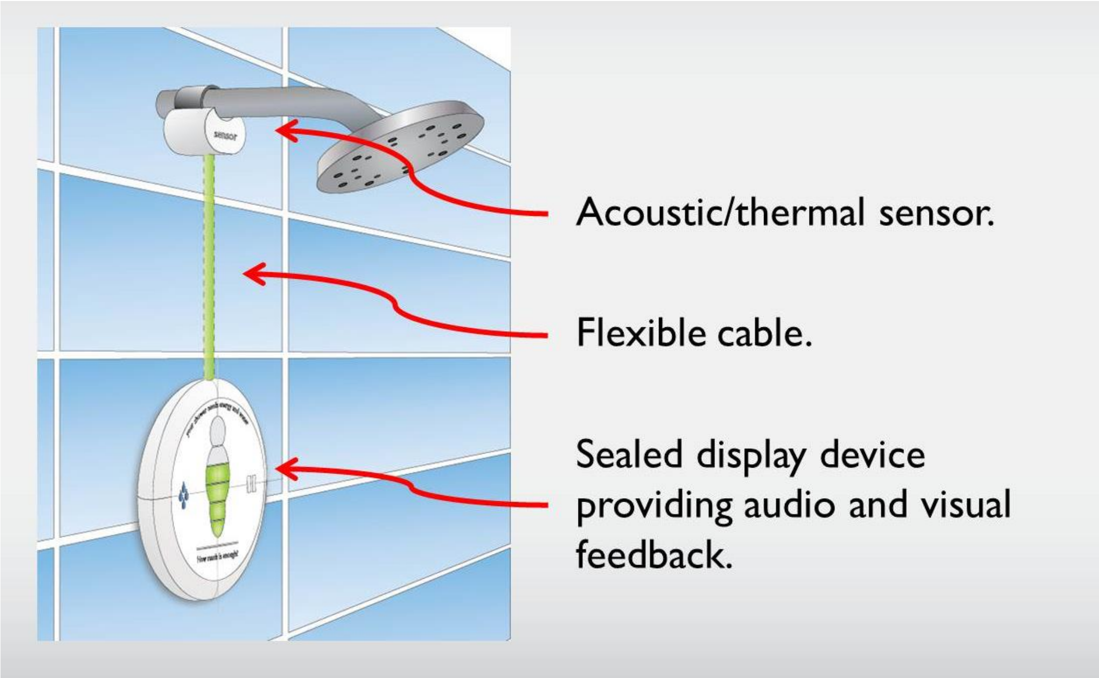


Figure 6-24. Overview of the major components.

The device achieves its automatic nature by constantly monitoring acoustic and thermal variation in the shower head. When water is flowing the sensor will pick up the change in temperature and the distinctive noise and switch on the display unit. This display unit would provide both audio and visual feedback to the user, and is shown in Figure 6-24.

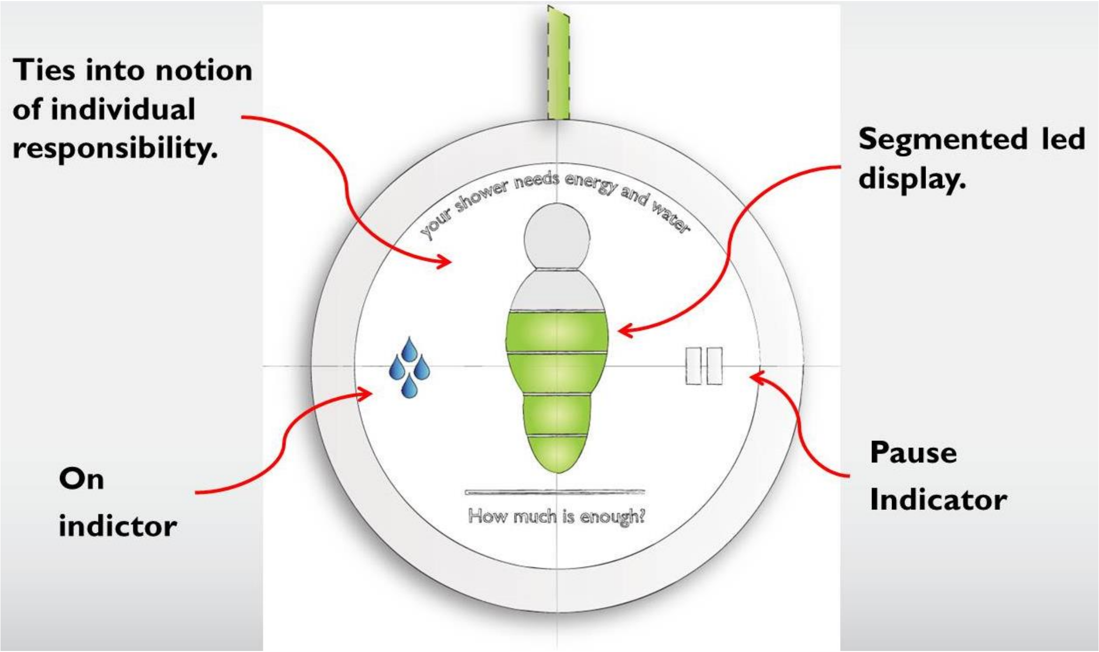


Figure 6-25. Enuf display unit features.

The main feature of the unit is a segmented LED display shown in Figure 6-25. This LED display progressively illuminates as time passes, showing the user how long the water has been running in an immediate and pre-attentive way. The display uses traffic light colour coding (green, amber and red) to denote the undesirability of longer durations. That is to say, the device takes a moral stand (targeting normative goal frames) on what is a good level of consumption (green, 0-3mins), a reasonable level of consumption (amber, 3-6mins) and a bad level of consumption (red, 6-9mins). The initial timing suggestions for each were chosen somewhat arbitrarily, but referenced some of the quickest times spoken about by participants and in the literature as a benchmark for good behaviour. It was not known at this point whether these timings would be attainable enough to act as a motivational spur for users to reduce their shower times. However it was intended that these timings would be verified or corrected through a pilot testing phase akin to a technological probe (Routarinne & Helsinki 2006).

As the intervention primarily takes the form of a persuasive feedback device, it is limited in terms of how it can actually enforce or reconfigure showering behaviour. As such, it relies on a high degree of obtrusiveness to insert itself into the user's situational behaviour, bringing them back to a reflective state and the goal of showering efficiently. Audio feedback was used to generate this level of obtrusiveness. Chimes, beeps, klaxons and reward sounds were all used at different stages to spur or deter different behaviours. These noises were more than just feedback, but were selected to be persuasive in various regards.

For example, the problem behaviour of people leaving the shower run unattended to make sure it was warm was addressed by the introduction of a loud chime when the water temperature reached 35degrees. This, combined with the device lighting up and displaying the previous user's duration, focussed the user's attention on getting in and beginning to clean themselves.

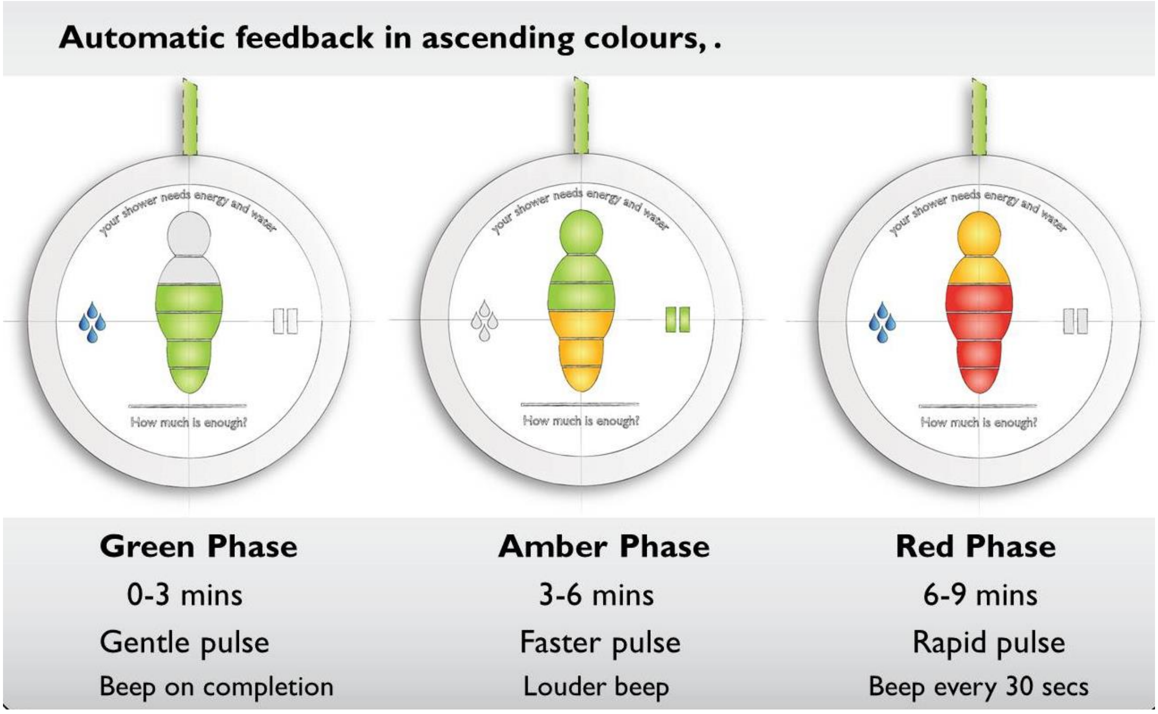


Figure 6-26. Enuf time segments and alerts.

Short beeps were used at the transition of one 30 second segment up to the next and reinforced by the progressive illumination of LEDs in each segment, as shown in Figure 6-26 above. This allowed users to keep track of time passing even though they may be facing the opposite direction or thinking about something else. In order to differentiate and reinforce the moral distinction between each of the colour phases (i.e. green, amber and red) a number of loud klaxon sounds would issue corresponding to how many minutes had passed. Thus when transitioning from the green section into the amber section after 3 minutes, 3 klaxons would sound, when going from amber to red 6 would sound. These were intended to be mildly unpleasant, and something that the users would perhaps try to avoid.

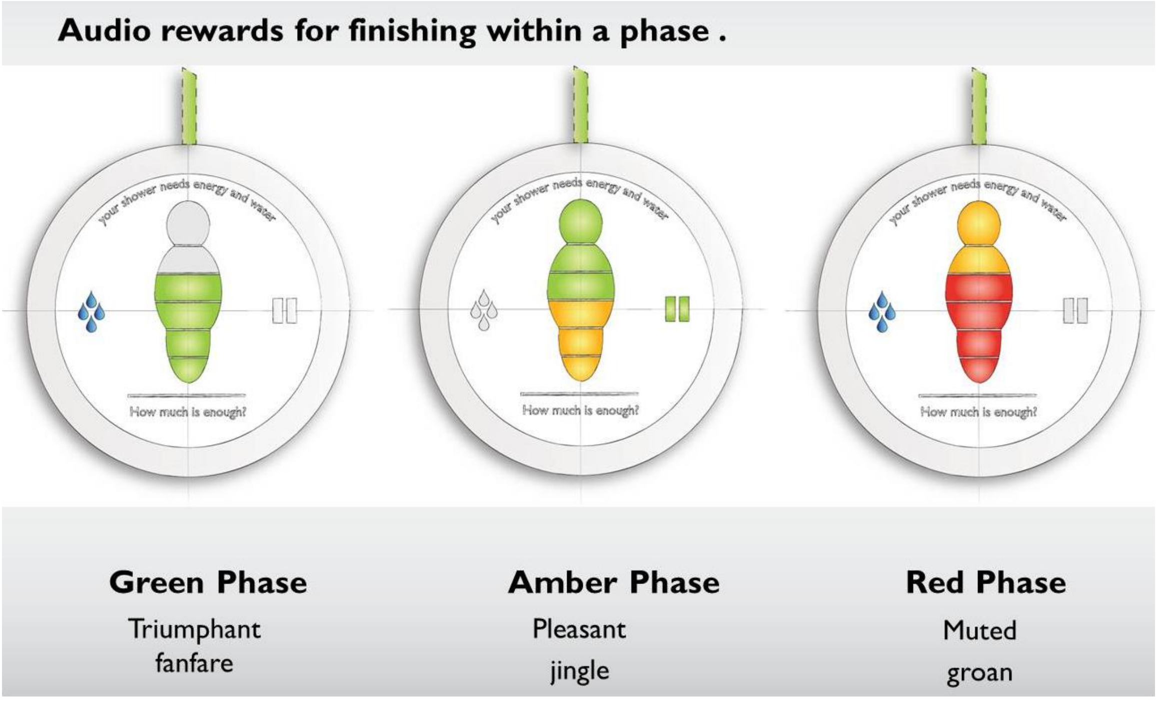


Figure 6-27. Enuf audio finishing sounds.

While audio was used to give the intervention the required degree of obtrusiveness in guiding the user to shower in a shorter duration, it was also used to provide a final assessment of their performance, see Figure 6-27. Thus, users who finished showering within the green section were played a triumphant fanfare with applause, to signify that they had done something good. Users who finished in the amber section, still below the average time reported in the literature, were also played a positive noise but one which was less exciting. Finally, anyone finishing in the red section or beyond was played a negative muted groan. These sounds were used to add a degree of personality to the device, which was hoped to appeal to younger users, as well as perhaps the more competitive users. They were also used to reinforce the cumulative effect of their behaviour to the users after they had completed their shower. Moreover, it was thought that they might be heard by other members in the house which might add to the competitive motivation.

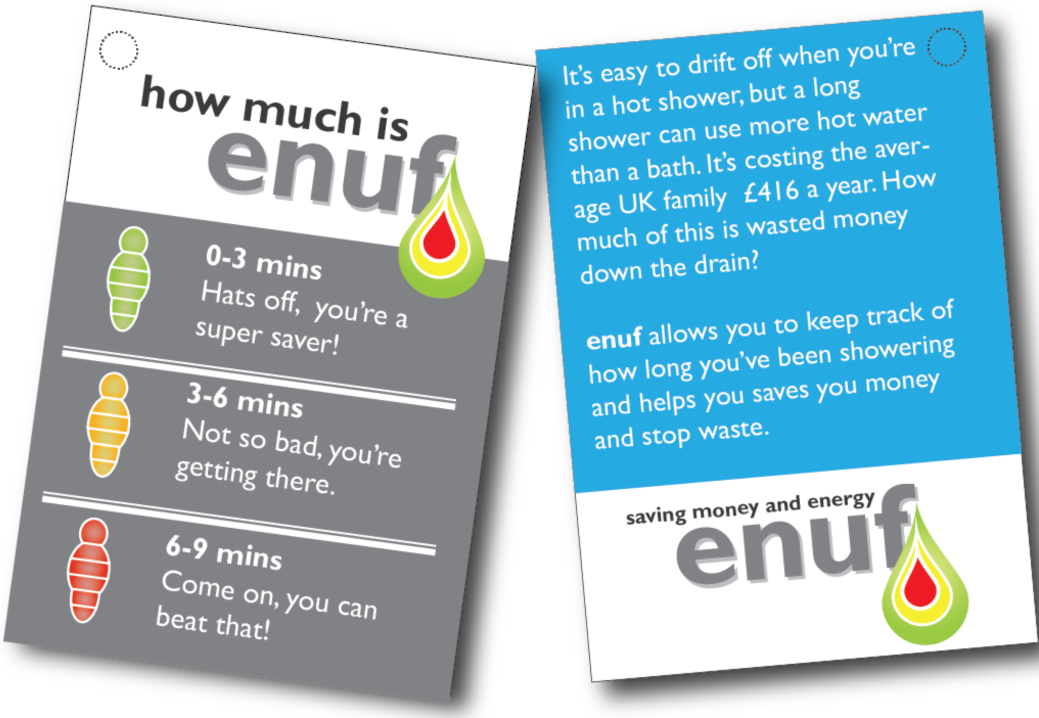


Figure 6-28. Enuf information card.

One factor uncovered was the fact that participants did not seem to connect using the shower with having an impact in terms of energy use and the associated cost and environmental implications. This required additional information to be attached to the device which could frame the device in these terms and awaken associated normative and gain based goal frames. This was done in the form of a waterproof graphic shown in Figure 6-28. While the automated persuasion delivered by the device should be clear in its intent, only further testing will asscertain whether users see the cost and enviromental benefits implicit in using it.

In order to evaluate the effect of this intervention concept, the device would need to incorporate a data logger which could measure the date, time, duration and temperature of each shower. This would provide a clear quantitative indication as to whether the persuasive means utilised had an effect on participants' showering times. Given that many participants spoke of having regular showr routines and times, it may be possible to extrapolate indiviual use patterns from the quantitative data. In addition, qualitative interviews with participants could be used to provide insight into the nature of any affect the intervention had.

6.5 Intervention Selection

The non-trivial challenges inherent in creating, testing and producing a number of innovative prototypes, meant that it was decided to just pursue one of the concepts for further real world evaluation. The selection process was driven by the criteria outlined in chapter 6.1.2.

The first criterion to assess was that the desired alternative behaviour was possible. In the case of the AirDry concept, this equated to participants ceasing to use their tumble dryer and using the intervention concept instead. Of all of the concepts, this seemed the most challenging behaviour to predict occurring as the dehumidification technology had not been widely verified as achieving the same goals as existing tumble driers. In the case of the Warm Home concept, it seemed quite likely that it would be possible for participants to reduce their heat settings somewhat, but there remained uncertainty as to how far, if at all, they would. The Enuf showering intervention which aimed to get users to reduce their showering times seemed the most likely to succeed in this regard as it provided a number of target levels, all of which could have resulted in a reduction of time.

The second criterion was that there be a defined energy gain if possible, through the use of the intervention. This has two elements, one that there is a reduction in energy consumption, and secondly that it can be defined, that is clearly separated and attributed to the intervention. Again due to the unproven technology behind the AirDry concept, this placed last in this regard. The Warm Home concept also fared poorly in this regard, due to the manifold variables that determine heating consumption, e.g. building fabric, ventilation, weather, occupant behaviour etc. These many factors would make it difficult to definitely attribute any reduction in energy consumption to the intervention alone.

Due to the single point of interaction, the Enuf concept was deemed to be the first choice in this respect.

The third criterion was that the intervention effect a measurable change in user behaviour. Again due to the manifold variables mentioned previously, Warm Home was considered the weakest concept in this regard. The AirDry concept was ranked second, and the Enuf concept was ranked first. This is because the Enuf concept only had to measure a single variable in behaviour change, i.e. change in duration of the shower.

The final criterion was that the intervention be technically feasible to make given the available resources of the research project. Further investigation revealed that the integration of the digital application with the home heating controller in the Warm Home concept could require more financial and technical resources than available, as well as a longer development period. The AirDry concept was considered more achievable as the digital component did not need to control any technology but could merely utilise the API of the AlertMe smart plugs and an online weather forecasting service to deliver its functionality. However, it was physically the largest intervention, and would have been extremely challenging for this researcher to realise in sufficient quantities. As a standalone monitor and feedback device, the Enuf concept was considered the most technically feasible, even though it was to be placed in an extremely inhospitable environment for electronic componentry.

These rankings were collated in a matrix (see Table 6-2) and the Enuf concept was chosen for further development.

Table 6-2. Intervention Selection Matrix

DfSB Intervention Criteria	Warm Home	Airdry	Enuf
Alternative behaviour possible	2	3	1
Defined energy gain	2	3	1
Measurable change	3	2	1
Technically feasible	3	2	1

6.6 Intervention Development

A detailed functional specification was developed for Enuf, the chosen concept. This detailed both the overall system requirements needed for the intervention to work in the context of the shower, as well as a comprehensive list of the specific functional attributes required at each stage of the showering process. This design specification can be seen in Table 6-3 below.

Table 6-3. Enuf Design Specification

System Requirements
1) Live feedback +/- 5 seconds
2) Data logging of shower times and durations, also ideally water quantity and energy consumed
3) 30 day installation life (power/data capacity)
4) Illuminated 3 colour display
5) Audio output
6) External casing water proofed housing
Detailed Functional Specification
1) Automatic Power-On:
a) Initialised by water flow [thermo sensor]
b) Display previous person's usage total.
2) When water heats up to 35˚ (thermo sensor):
a) Audio signal (long beep)
b) Hot water icon illuminates
c) Main display begins count from blank screen
3) Main display Countdown:

a) Section metrics time: 30 seconds of hot water flow

b) Sections displayed as per below

Section #	Green	Amber	Red	9 mins +
Transition Sound	3 Klaxons	6 Klaxons	9 Klaxons	n/a
6	LEDs Beep	LEDs Beep	LEDs Beep	Full red display Flashing, Beep
5	LEDs Beep	LEDs Beep	LEDs Beep	Full red display Flashing, Beep
4	LEDs Beep	LEDs Beep	LEDs Beep	Full red display Flashing, Beep
3	LEDs Beep	LEDs Beep	LEDs Beep	Full red display Flashing, Beep
2	LEDs Beep	LEDs Beep	LEDs Beep	Full red display Flashing, Beep
1	LEDs Beep	LEDs Beep	LEDs Beep	Full red display Flashing, Beep
Finish Noise	Fanfare and applause	Pleasant Jingle	Sad Trombone	Sad Trombone

4) Flow stops:

a) Pause indicator illuminates

b) After 2 minutes
   - i) Final reading flashes x 5
   - ii) Completion alerts play
     - (1) Green – fanfare and applause
     - (2) Amber – pleasant jingle
     - (3) Red – fail sound effect

As the intervention required a level of electrical engineering beyond the abilities of the author, this specification was brought to an external supplier to be translated into functional electronic componentry. Early discussions showed that using an acoustic sensor to determine water flow was technically unfeasible from this supplier. Therefore a thermistor was used to detect the flow of hot water and initiate the persuasive feedback. Due to the low volume of prototypes to be made, the intervention made use of Arduino microprocessors with bespoke boards developed for LED and sound feedback. The author researched and modified Creative Commons sound files which reflected the intent of the concept design, and these were given to the supplier to incorporate into the technology platform.

The form of the intervention had to be changed based on the size of these components. In addition, the need for the device to function for a period of 3 weeks at a time required the installing of 3 large D-cell batteries, which added significantly to the weight and volume of the unit. This extended running period was considered vital to accurately monitor usage patterns without excessive interference from the researcher and addresses one of the weaknesses of other interventions in this area (see Arroyo et al. 2005).

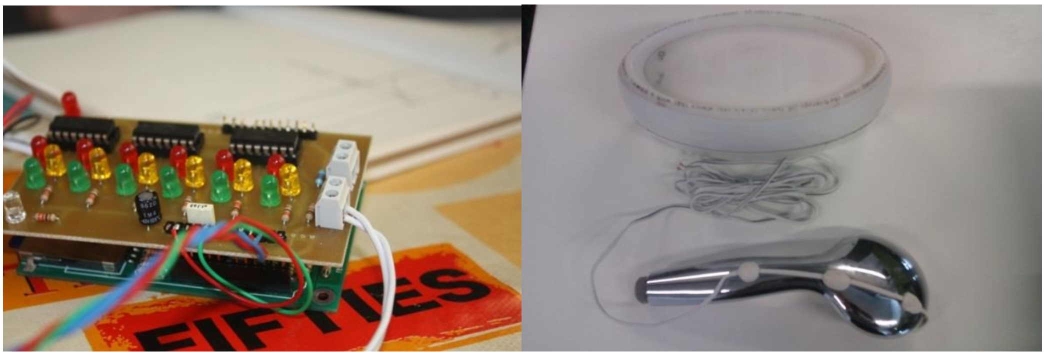


Figure 6-29. Enuf prototype internal electronics and external form.

This change in the scale of the internal componentry necessitated the development of a new form for the external casing. This form was designed and manufactured by the author using the workshop facilities in Loughborough Design School. Considerable effort was put into ensuring the water-proofing of the unit to protect the internal components from water and vapour ingress in what is an extreme environment for electronics. As can be seen in Figure 6-29 above, the design required the thermistor to be pre-attached to a shower head so as to ensure its correct positioning in the water flow. The shower heads were installed with the intervention, replacing the existing shower head in the test location.

Figure 6-30. Early testing of prototype with improvised water-proof housing.

The units were bench tested and calibrated extensively to ascertain their reliability and the accuracy of the recording. They were also tested in the researchers own shower (see Figure 6-30 above) to further evaluate the functionality in context. Some modifications were made to the volumes of the sounds to ensure they could be heard within the shower environment.

6.6.1 Pilot Trial

As user testing and design iteration are cornerstones of the user centred design process (IDEO 2009; Wever et al. 2008; Wilson et al. 2013), it was decided to conduct a pilot trial of the intervention prototype in a real world setting before producing multiple units to be installed in the LEEDR project participant households. This trial sought to find out if the design would function as intended for an extended period in an uncontrolled real world setting. It also sought to gain insight into how real users would perceive the intervention and what, if any, changes in their behaviours were resultant. Particular attention was paid to ascertaining if the timings allocated to the various sections on the device (i.e. green, amber and red) had the desired motivational impact on the user.

The intervention was installed in the house of a colleague from Loughborough University on 13th April 2013 (see Figure 6-31 below). The house was owned by this colleague but was also shared with two lodgers. All the occupants were in their 30s, two were British males and one was a Slovakian female. The occupants were informed that the purpose of the trial was to evaluate the technology to see would it work in a real life context. They were not told much about the overall aims of the research, but rather it was decided to see what their reaction was to the device without being primed.

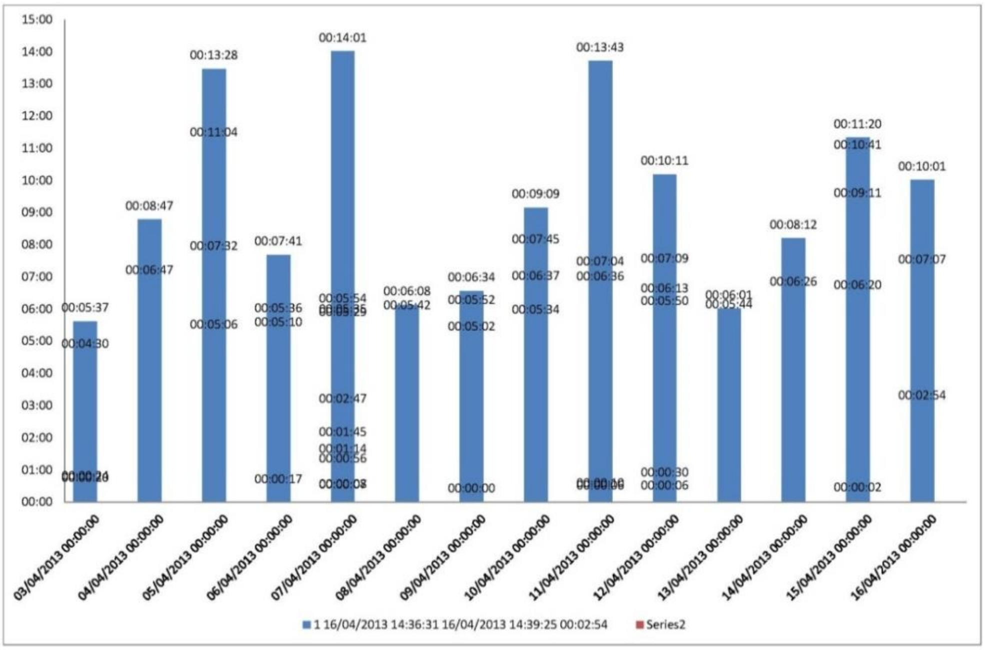
Figure 6-31. Pilot trial installation.

Technical Evaluation

The device functioned well in the trial, reliably giving audio and visual feedbacks at the correct times, and recording data for the duration. However, the calculated battery life of 3-4 weeks was not achieved and the battery ran out after just 2 weeks. This was subsequently found to be an error in the electronics, which was corrected and allowed a full 3 weeks battery life in the main intervention trial. One technical issue highlighted by the participants in the qualitative evaluation (see below) was a certain amount of lag between the shower finishing and the thermistor cooling down enough to signal to the device that this had occurred.

The recorded data was processed and compiled into Table 6-4 below. This validated the accuracy of the device as a means of quantitatively recording user behaviour. This data was discussed with the occupants and the times and durations of the showers seemed to fit well with their own recollections.

Table 6-4. Quantitive results of shower duration from Pilot Trial



Qualitative Evaluation

A brief semi-structured interview was undertaken with the two male occupants of the house (PTMA1 and PTMA2) after the batteries had expired. The third occupant (PTFA) had returned to Slovakia and was not available to be interviewed. This was unfortunate as when the male occupants were shown the graph of results and queried about the longer showering times, they both said that these were due to PTFA. When asked if they knew why the device hadn't seemed to shorten her showers, they replied that she hadn't really understood it and had been told that she didn't need to worry about it by the home owner, PTMA1.

Unattainable Timings

One of the key things that this interview sought to find out was whether the persuasive nature of the feedback had had the desired effect on the occupants' behaviours. A central aim of this feedback is to make the user want to finish their shower quickly. There appeared to be some indication that this had been the case for the two male users but that the timings allocated to the segments, particularly the green segment, were unattainable. This was a very significant finding as unless the target behaviour can be realistically achieved, users are unlikely to engage further with the intervention.

> *"There was that side of it, you'd be nearly finished in the green, but it would just go into the yellow and you'd be like "Sod it, might as well stay for all the yellow!""* **PTMA2**

> *"I tried a few times, but you would need be to be as quick as anything to finish in three minutes"* **PTMA1**

Reward

Although the participants struggled to ever finish within the green section, when they did they found the finishing noise, the fanfare and applause, to be rewarding. This indicates that were it more attainable, that it could be an effective form of positive reinforcement that would encourage users to try and finish within this section.

> *"The cheer was good alright, it's quite nice first thing in the morning to get a cheer. Mind you it only happened once!"* **PTMA1**

Competition

One aspect which was not fully foreseen before the pilot trial was the socially shared aspect of showering. In a shared house, occupants can hear each other using the shower normally, and in the case of the intervention could also hear the feedback noises, particularly the finishing sounds. Interestingly, this led to an element of competition taking place where one participant spoke of listening out to make sure the other occupant hadn't been finishing in the green where he couldn't.

> *"When I'd be making my coffee in the morning I could hear PTMA1 in the shower and I'd be listening to see if he got a cheer"* **PTMA2**

Breaking Situationality

As driven by the Intervention Selection Axis, the intervention sought to use obtrusive audio feedback to break the deep situationality of some showering behaviours. This, it was hoped, would refocus the user's attention back to the reflective goal of finishing the shower quickly. Encouragingly, one of the participants described exactly this situation when questioned if the noises had had any effects on his shower behaviour.

> *"I wouldn't say I tried to speed up really, but you'd be there sort of thinking about the day and stuff and the three loud beeps would come in and you just realise that you've been standing in the hot water doing nothing. So yeah it would kind of get you moving again."* **PTMA1**

Technical Problems

A frustration expressed by the participants was the degree of lag between the shower finishing and the thermistor signalling to the device that this had occurred. This caused the device to keep counting and moving up through the coloured segments, even after the water had been switched off. This is a serious issue as it reduces the user's trust in the device and reduces their motivation to continue to try and finish within a given section.

> *"It's really frustrating, a few times I managed to finish in the green, but then, because of the lag, it would go into the yellow anyway! You'd get quite annoyed actually, because you'd thought you'd beaten it!"* **PTMA1**

Functional Problems

The participants found the volume setting of the device to be excessively loud and commented that it could wake up other occupants if it was used close to their bedroom.

This should obviously be addressed as it could lead to negative feelings towards the device, and even to participants disconnecting the device entirely if it was to wake up young children for example.

> *"Fortunately, I'm up before everyone else, so it never woke me or anything, but it was really loud alright. I could hear it perfectly in my room, even in the kitchen."*
> ***PTMA2***

In many respects the pilot trial can be considered successful in its purpose. It proved that the technology was broadly viable in the shower environment, and it also highlighted a number of key issues which were preventing the intervention from having the desired behavioural effect. Foremost amongst these issues was the unattainability of the metrics used to denote the different coloured sections. These must be corrected before the wider trial. Other issues to be addressed were the shorter than intended battery life, and the excessive volume of the audio feedback. One significant issue highlighted by the participants was the lag between the shower finishing and the thermistor cooling down enough to signal to the device that this had occurred. This problem is inherent in the configuration of the technology, and could not be changed for future iterations. Instead it was decided to inform participants in the wider trial that this was a teething issue due to the development of a new technology, to try to ameliorate any negative effects.

One issue that emerged after the pilot trial was the need for reliable and calibrated baseline data to establish showering durations and patterns prior to the introduction of a live feedback device. It is impossible to ascertain the degree of change of behaviour without knowing its original state. It had been originally planned that the monitoring work being undertaken by the LEEDR project colleagues in the School of Civil Engineering in Loughborough University would provide this data. However it transpired afterwards that their readings were less accurate and defined than those produced by the intervention itself. Thus it was decided to retrofit the intervention to act as a monitoring device for the 3 weeks of any trial. This would establish an accurate representation of the baseline showering behaviours.

Design Iterations

A number of changes were made on the basis of the participant feedback and quantitative data collected from the pilot trial.

1. The volume of the unit was reduced through the use of some sound insulation materials, see Figure 6-32 below.

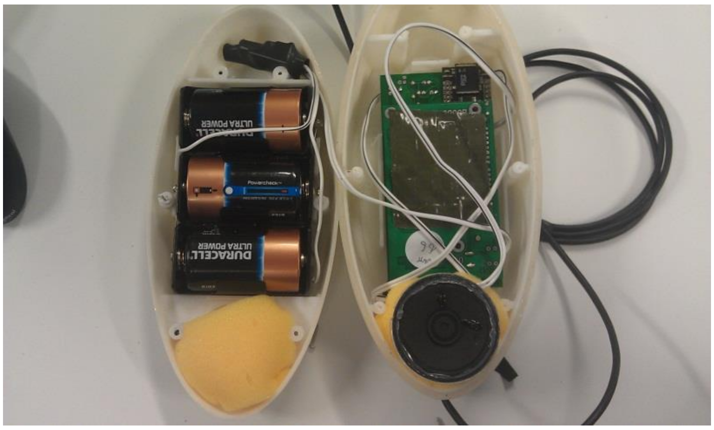


Figure 6-32. Sound Insulation used to reduce volume.

2. The duration of the sections was altered to make the green section more attainable. The timing was also used to add a sense of urgency to the later sections by shortening them in comparison to the earlier sections. The new durations are:

    a. Green section – 0-4.5 minutes
    b. Amber section – 4.5-7 minutes
    c. Red section – 7-9 minutes

The information cards were reprinted to display the new times (see Figure 6-33 below).

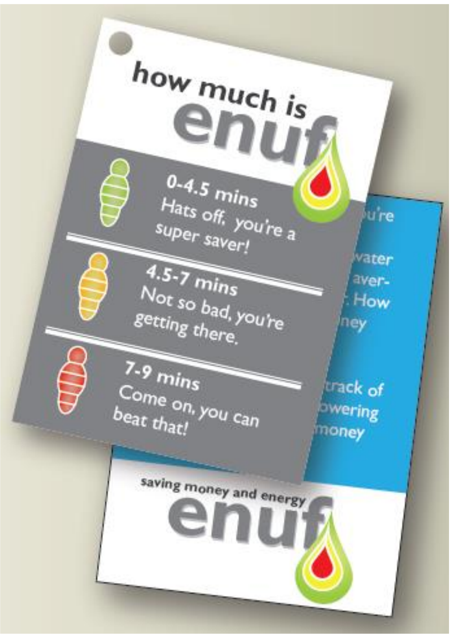


Figure 6-33. Revised time setting card.

3. The device was modified to allow for the collection of baseline data. This involved removing the sound card and placing a cover over the display rendering the unit dumb but still allowing it to collect quantitative use data, see Figure 6-34 below.

Figure 6-34. Enuf in silent mode for collection of basline data.

4. The shorter than expected battery life was traced back to a programming issue relating to the sound card. This was corrected, allowing the device to operate for a period of around 3 weeks, dependant on use.

6.7 Conclusions

This chapter has provided an overview of the intervention development process. It has fulfilled two of the research objectives of this body of work.

1. To create a suite of Design for Sustainable Behaviour driven concepts targeting reduced domestic energy consumption.
2. To concurrently test the design principles by using them as a designer.

The fulfilment of the second of these research objectives will be discussed first as it drove the development of the suite of DfSB concepts. The conceptual model developed from the literature and refined by the User Study findings, was employed in the design of all the concepts. The theory has provided a useful lens for viewing the complexity of energy consuming behaviours. It has allowed the author to categorise and prioritise the myriad factors uncovered in the User Study into a cogent set of attributes to populate the design space.

Through the application of goal framing theory, a large number of seemingly unrelated user motivations have been categorised into three major goal frames driving behaviour. This has enabled the designer to view these motivations in terms which can be more readily addressed through design thinking. It shows that the dominant goal frame is often tempered by other goals which can be leveraged through design to drive a change in behaviour. It also allows the designer to try and address the dominant goal frame through a less resource intensive means. For example, the Warm Home concept recognised the strongly hedonic goal frame driving central heating behaviour, and substituted situated personal heating artefacts to address this.

The Behavioural Intervention Selection Axis (BISA), was used to categorise the nature of recorded behaviours and to select appropriate intervention strategies to address them.

The descriptors used to define reflective and situational behaviour are intentionally broad to enable the designer to interpret them against recorded behaviours. This combined with the sliding scale allows the designer to intuitively place behaviours in the position they feel best describes them. This is an extremely useful feature in terms of generating design interventions as it removes the need for extensive psychological evaluation of a given behaviour. In comparison, Verplanken & Orbell's (2003) Self-report Habits Index involves a lengthy list of specific questions, framed in complex language, to ascertain the habitual nature of a single behaviour.

The high level nature of the intervention strategies aligned to the BISA also facilitates rapid and creative design conceptualisation. Rather than specifying that a particular form of behaviour requires a specific form of intervention, the high level intervention strategies guide the designer to configure a strategy that best addresses the unique aspects of the behaviour. This is particularly true when considerations, such as the required level of obtrusiveness, are brought in. For example, concept 3 Enuf, could be viewed purely as a feedback device, and as such would not address the situational behaviours it was intended to. However, by allowing the required level of obtrusiveness to guide the design, it was found that temporally appropriate audio feedback could indeed be used to break this situationality. This contrasts with the Consumption Behaviour and Design Interventions Framework (Tang, 2010) which places feedback and eco-spur interventions as only being suitable for less situational behaviours.

The concept of using auxiliary strategies to support interventions targeting particular existing behaviours is one which has proved both useful and valid. It stands to reason that if an existing behaviour is driven by both contextual and motivational attributes that it would not be sufficient to just change one of these aspects. For example, in Concept 2 AirDry, a high degree of contextual change would be implemented to break the situational aspects of existing tumble drier use, but it is necessary to also use the reflective intervention strategies to inform and persuade the user to adopt this new technology.

The revised model also incorporates Wever et al's (2008) concept of functionality matching. This has proved very useful in looking past the existing technical paradigm to see what function a user requires from a given product area. It allows the designer to explore other means of delivering the same core functionality, means which may be more suitable for DfSB intervention strategies.

Enuf shower intervention was chosen as the concept to proceed to further development and has been through a thorough development process. Developing a fully functional electronic prototype was a prolonged process requiring that a large number of technical challenges be overcome on many fronts. The process covered by this chapter took an entire year and impacted heavily on the research's rate of progress. However, inherent technical limitations of the intervention aside, the intervention was made ready for the extended trial in the participant households.

The intervention development process has fulfilled the UCD approach outlined for DfSB (Wever et al. 2008; Wilson et al. 2013) and the design has gone through one round of real world testing and iteration prior to the main trial. This level of development is already more advanced than a number of the proposed intervention designs within the DfSB cannon.

7. Design Intervention Evaluation

This Chapter seeks to answer the following objectives from chapter one:

6. To concurrently test the Design for Sustainable Behaviour intervention selection model suitability for use by designers.
7. To create a Design for Sustainable Behaviour driven prototype targeting reduced domestic energy consumption.
8. To test if the design interventions have been successful in reducing energy consumption though a combination of quantitative energy use measurements and qualitative contextual study.

7.1 Introduction

This chapter outlines and discusses the evaluation of the design intervention in a real-world medium length setting. It first describes the nature of the intervention trial, the aims and objectives of the study, its scope and limitations, the evaluation criteria and the study implementation.

Secondly it will present the results and findings resulting from the trial. It outlines the results of the trial on a family-by-family basis, giving some indication of the response of each of the trial families to the device as well as outlining the quantitative data gathered by the device.

Thirdly an in depth discussion positions and validates the intervention trial within the theoretical framework guiding this research. It evaluates the effect of the device across the sample through the lens of the conceptual model and the Behavioural Intervention Selection Axis. Subsequently, it also evaluates the effect of the intervention against the criteria outlaid in Wilson's (2013) DfSB evaluation.

Finally conclusions are drawn against this evaluation showing the relative successes of the trial, and the emergent relevance of the theoretical contribution to the field at large.

7.2 Intervention Trial

The primary goal of the trial was to evaluate if the design intervention was successful in reducing energy consumption though a combination of meaningful quantitative energy use measurements and qualitative contextual study. In order to achieve this, the following steps were completed:

1. The recruitment of a number of families to participate in a 10-14 week trial.
2. The installation and maintenance of the intervention device in every commonly used shower in the family homes.
3. The recording of quantitative baseline showering data for a period of at least 3 weeks.
4. The deployment of an active intervention device for a period of at least 6 weeks and the recording of quantitative showering data during this active period.
5. The undertaking of in depth qualitative interviews with the participating families at the end of the intervention period.
6. The analysis of all quantitative and qualitative findings against the theoretical underpinnings guiding the design of the intervention.

7.2.2 Scope and limitations

The scope of this intervention trial was designed to be broader than previously embarked upon in the field of DfSB. It sought to test fully functional digital prototypes in multi-occupant houses for an extended period of time, while gathering clear quantitative use data. While other studies in the research area have trialled digital interventions in context (e.g. Wilson, 2013), none have been able to provide reliable quantitative data on changes in resource consumption.

In order to provide some meaning to the collected quantitative data, an in depth interview was carried out with each of the participant families at the end of the trial. This sought to evaluate their response to the unit, as well as providing clarity on when and how the respective participants engaged with the device.

As outlined in chapter 6.7, the intervention specifically targets a reduction in the duration of hot showers. It does not consider or try to effect change in other aspects of showering which have an impact on energy and resource consumption, e.g. flow rate, temperature, heat source, etc.

As this is a real world trial, a number of technical limitations had to be observed in the creation and deployment of a functioning intervention. Due to cost and time issues, the number of intervention devices was limited to 10 units. Of these 10, only 9 were deployed in the field at any one time allowing for one unit to be kept as an emergency back-up if a replacement was needed. As these 9 units were going into family homes, it was crucial that every regularly used shower in each home had a functioning intervention connected to it. As explained below in section 7.2.3, this limited the number of houses to six as some houses had two showers.

In order to evaluate the effect of the device on behaviour over time, the trial was designed to run for an average of nine weeks in total. Of this, the first three weeks were used to collect baseline consumption data and for the following six weeks the device actively gave consumption feedback. While it would have been desirable to trial the device for longer, the technical limitations of the device in such extreme conditions and the resulting imposition on the participants meant that this was considered the most feasible period.

As the intervention device was trialled in multi-occupant households, it was apparent that a number of participants would be using each shower. However, it was impossible for the device to differentiate between these users while maintaining its automatic always-on nature. Every effort was made to attribute different showering times to different users during the qualitative interviews following the trial. A further physical limitation of the trial was its geographical range, all participants lived in the East Midlands region of the United Kingdom.

Furthermore, as the device was developed with limited technical and financial resources, there were a number of limitations inherent in its design. These limitations were unavoidable and were due to the technical challenges in building a sophisticated digital design intervention to reliably work in a very challenging environment; the shower. One of the chief limitations was safely delivering electrical power to the device over an extended period of time. The final compromised design solution used three large D cell batteries which powered the device for around three weeks, depending on the frequency of use. This required the researcher to visit the participants' homes and disassemble the device to change the batteries every three weeks. This was far from optimum situation as any external contact with the researcher could be seen to be an external influence on the participating families' behaviour. All reasonable steps were taken to avoid this.

7.2.3 Study implementation

The intervention trial took place in the homes of six participating LEEDR families between July and November 2013. The intervention trial followed the same format in each household, excepting occasions when the device malfunctioned. Extraneous contact between the researcher and the participants was kept to a minimum in order to not unduly influence the results. The participants were told that the researcher was not the designer of the units, but just "wanted to find out if these devices worked in real family homes". This was done to mitigate any motivation the participants might have had to please the researcher by behaving more "sustainably".

When the device was installed the water flow of the shower was measured to allow for the extrapolation of water usage data from the recorded durations. Generally only one householder was present for the installation, and the working of the device was briefly explained to them. At this point, arrangements were made to come back and replace the batteries in around three weeks' time.

Figure 7-1. Device in Passive mode gathering base line data.

When first installed, the device was described as being in 'learning' mode, its LED display was covered and the sound chip was disabled (Figure 7-1). This meant the device arrived as a dumb monitoring device, and did not provide any feedback to the participants for the first three to four weeks. During this period, the device was still actively monitoring and recording the time, date, duration and temperature of all hot showers. This information was used to collect a base line of data showing what the participants' existing showering routines looked like. This allowed for a clear comparison between participants' shower times without any persuasive feedback, and their subsequent times once the device was actively giving audio and visual feedback to them.

After the first three weeks, the batteries were changed in the device and the monitoring data was downloaded onto a separate computer. At this point the blue plastic cover was removed and the sound chip was inserted. This allowed the device to give active audio visual feedback when the shower was running (Figure 7-2).

Figure 7-2. Device in Active mode giving audio visual feedback.

In order to get the most meaningful data possible, this active phase was continued for six weeks in total requiring one more battery change to occur.

At the completion of the six week active period, a final semi structured group interview was arranged to take place with the entire household at a time of their convenience. This often took place over a week after the device had run out of power for the final time, and provided some insight into their behaviours subsequent to the intervention. The group interviews took place in the family homes with all participants present where possible.

Technical Issues during the Trial

As one would expect with the field deployment of a novel technology in such a challenging environment, the devices experienced some technical issues over the course of the trial. A certain amount of corrosion and water ingress affected the units in H45 and H46, but these were quickly remedied following notification from the householders. Fortunately, these outages did not leave too large of a gap in the recorded data, as can be seen in the results plotted below in section 7.3. Unfortunately, and more seriously, two of the devices failed to record the final three weeks of their active period, they continued to give feedback but the devices did not collect data. These were the devices in the main bathroom of H46 and in the Ensuite bathroom of H43. The technology did not reliable work in H28 at all, this was due to the occupants showering at a lower temperature then the device recognised as the start of a shower. Thus in this one house no reliable data was recorded.

7.3 Results and Findings

The devices recorded the date, time, temperature and duration of every time a shower was turned on and reached a temperature of 35° C or higher. These results were processed and plotted on to a series of graphs to capture the longitudinal impact of the device of showering times. These graphs provide a clear indication of what happened in quantitative terms, but they do not necessarily show us why these things happened. In order to gain insight into the human responses guiding the behaviour it was necessary to undertake an in depth group interview with the families. These interviews were transcribed and coded according to the evaluation criteria and any emergent themes.

In order to properly understand the data collected by these devices, it is important to first contextualise it with an understanding of the families that produced it. For this reason, each of the participating households and their relationship with the intervention device will be outlined in narrative form below. Using narrative form helps give meaning to data of this type and places it back in the human realm where it originated (Bruner, 1990).

7.3.1 H37

02/08/13 to 17/10/13

H37 lives in a village on the outskirts of Loughborough. The family consists of H37MA and H37FA and their two daughters, H37fc1 and H37fc2. MA is an engineer and a selfconfessed data freak, and was really looking forward to the arrival of the device as he loves 'anything that will show him what's actually going on' in terms of energy consumption. The females in the family are considerably less interested in consumption data, but were still curious and a little bit excited about the device's arrival.

When it first arrived, mother and daughters explored all the different sounds and lights, and found the noises to be fun and amusing. MA had been looking forward to seeing whether he was in the orange section (4.5 – 7 minutes) and if so, if he'd be able to get down into the greens (less than 4.5minutes). However, he found that he was always in the greens except for one or two incidences. This slightly frustrated him as he is very competitive and was looking forward to the challenge of pairing back his showering routine to the bare minimum, but felt that being already comfortably in the green didn't give him much motivation. Having said that, he enjoyed the sense of time and company it gave him, and over the course of the trial became very fond of the device, even referring to it as Wilson, the inanimate beach ball friend from the movie Castaway (2000).

Fc2, the youngest in the family, liked the noises and mainly finished in the greens with some oranges reported. She said that the device made her shower quicker, which was good because now she had more time for watching TV.

Her elder sister, in her early teens, had enjoyed longer showers, up to 10-12minutes, before the arrival of the device. However, when the device arrived she reduced these longer showers and aimed for the middle of the orange section instead.

FA was perhaps more ambivalent about the device than the rest of her family. As a busy mother, showering provided a rare moment of isolation and quiet. However the arrival of the device somewhat changed that and she commented that it added a sense of pressure to showering. She felt that the device did speed her up a bit, but not dramatically, and that often she would mentally block it out and not even hear the noises.

Both parents commented that the 'water is hot' alert was very useful and that as their boiler could take a while to come to temperature, that they did sometimes go off to do little jobs while they were waiting for the water to get warm, and that this alert had solved that. On the other hand, the physical effect of the device in twisting the shower head out of alignment was the most annoying thing about the trial for the participants, and design changes would be needed to address this.

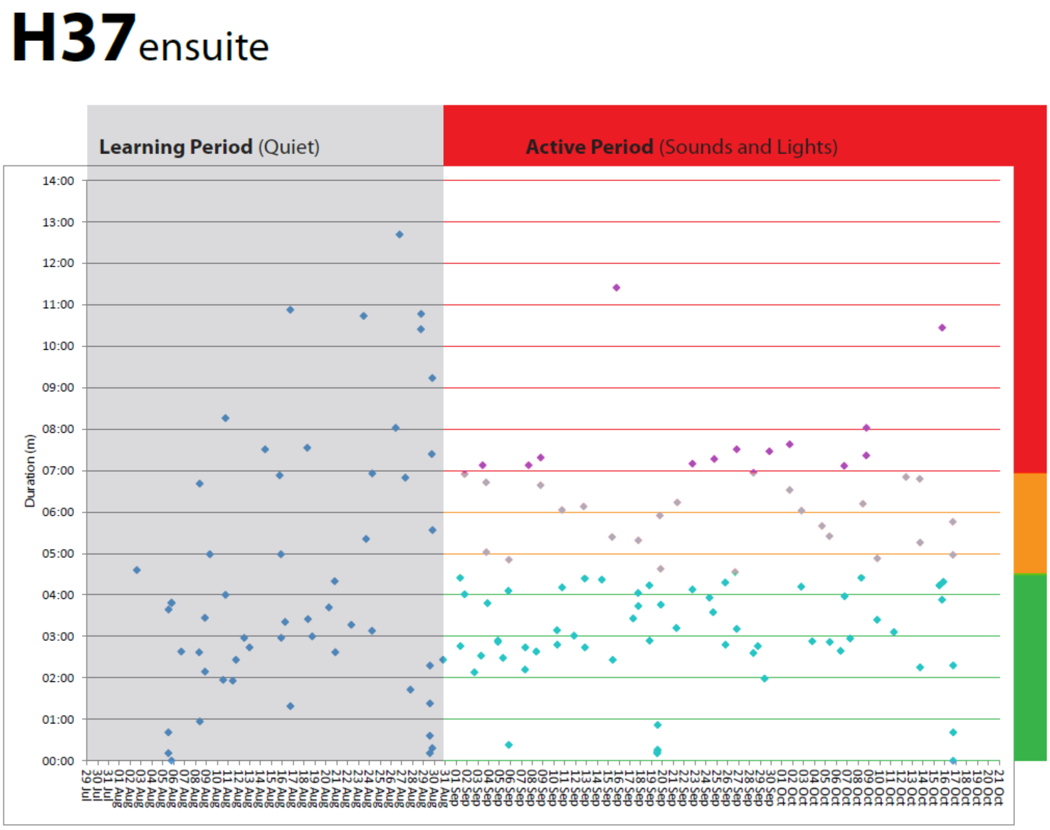


Figure 7-3. H37 Ensuite bathroom intervention trial results.

As can be seen in the results in Figure 7-3 above, the showering times have flattened off from regularly being above eight minutes, to coming down to the cusp of the red section. In reality, due to the lag on the device's thermistor it is likely that most of the results are actually around a minute less than the reading which would put more showers in the orange section as reported by the family. This reduction in longer showers can be seen in the comparative charts of Figure 7-4 below.

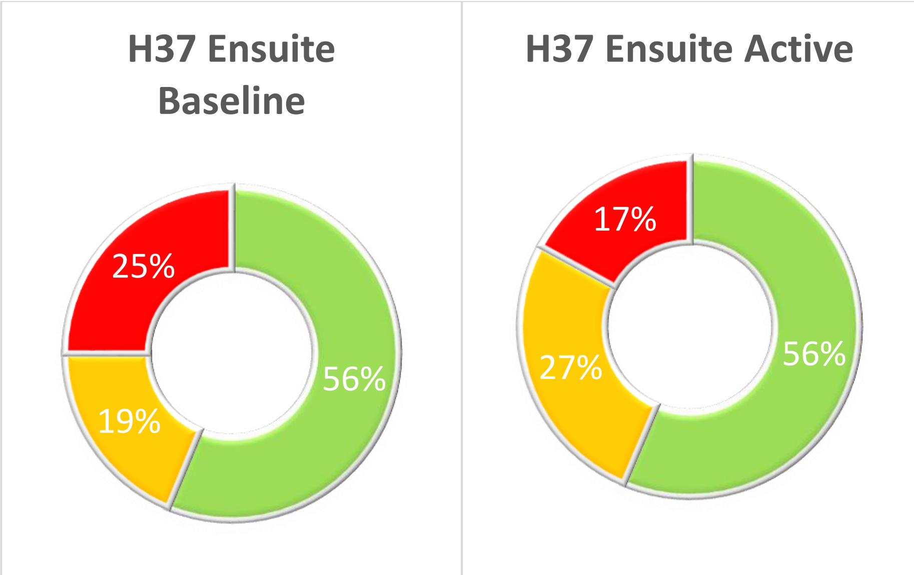


Figure 7-4. H37 Baseline and Active shower durations by colour band.

7.3.2 H40

02/08/13 to 17/10/13

H40 live in a semi-detached house in Loughborough town. The family consists of H40MA and H40FA, and their children H40fc in her early teens and H40mc aged eight. When H40 agreed to trial the intervention in their home, MA said that he didn't think it was going to work for their showering practices. This was not a statement of intent on his part but a reflection of how he understood the family practises would interact with the device's metrics. In the event he was proved largely correct, at least in quantitative terms.

The device was fitted to both the bathroom and the parent's Ensuite bathroom. MA had said how both children mainly used the Ensuite bathroom shower and so the bathroom shower was rarely used. The Ensuite bathroom shower was a large walk-in type with a large fixed shower head and a second movable head. The device was only able to be connected to this movable head, which was said to be used the most. However, after the trial it turned out that both parents primarily used the un-monitored shower head, and so had limited engagement with the device themselves.

FA said that the majority of her showers didn't involve washing her hair and were fairly quick. When she did was her hair, she used the monitored shower head, but because she switched the water off while conditioning her hair, the device would read it as two separate green showers. She was conscious enough to count how many segments each of these two micro showers used, and reckoned that it was between 4 and 5 minutes. While MA said he only used the monitored shower head a couple of times, he said he had always been in the green.

Mc, the youngest in the family, said that he got greens every time, but fc, the teenage daughter admitted to taking longer, and going into the oranges and reds. She remarked that hair washing was the reason for her going into the red, and that showers where she wasn't washing her hair were quicker. She also talked about how, during those longer showers, the transition sound between orange and red would startle her out of her daydreaming and cause her to speed up to try and finish quickly.

The family also spoke about some of the different practises that occasionally happened, which would give unusual readings. Sometimes, one person would leave the shower running for the next person to jump straight into, which would result in a reading of one very long shower. Occasionally, father and son would shower together if they were in a rush to go somewhere and MA needed to get mc ready quickly. Another reason they felt the device didn't have a big impact was that the parents already had a form of monitoring the length of the children's showers, or "watchdog system" as they called it. The water pump powering the shower was very noisy and could be heard all over the house. Also when the pump was on, the taps downstairs developed huge pressure and couldn't really be used. This caused the parents to regularly shout up to their children to hurry up and get out of the shower.

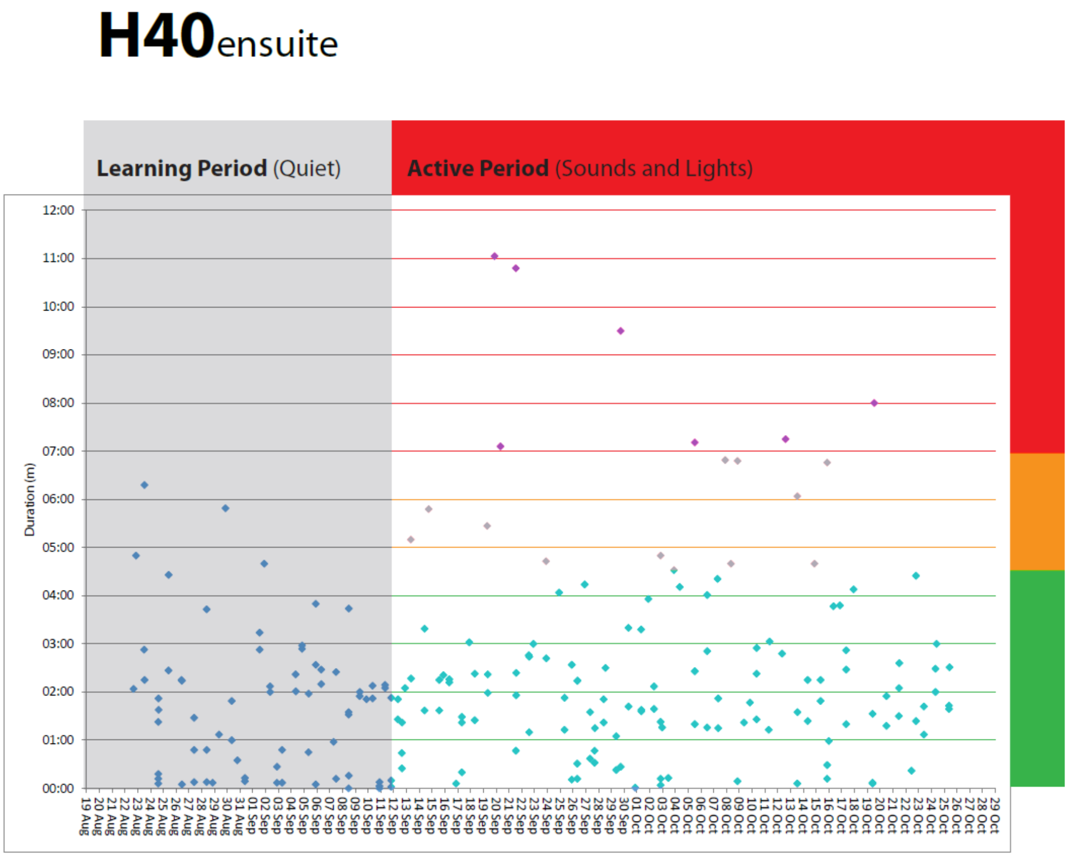


Figure 7-5. H40 Ensuite bathroom intervention trial results.

As can be seen in Figure 7-5, the results show if anything an increase in duration with the arrival of the device. This is difficult to align with participants' accounts of the their reaction to feedback they received and the times they recorded but maybe accounted for by practises like leaving the shower running for the next person, or maybe just reflect the fact that the device did not map well with the routines of the family. As can be seen in Figure 7-6 below, there is an increase in the occurrence of red showers during the active phase. Both FA and fc reported going into the red when having a long hair wash and perhaps these long showers just reflect this occurring however this does not account for the lack of red showers during the baseline period. It is possible in this house that some participants switched from the unmonitored shower head to the monitored one for the duration of the active phase.

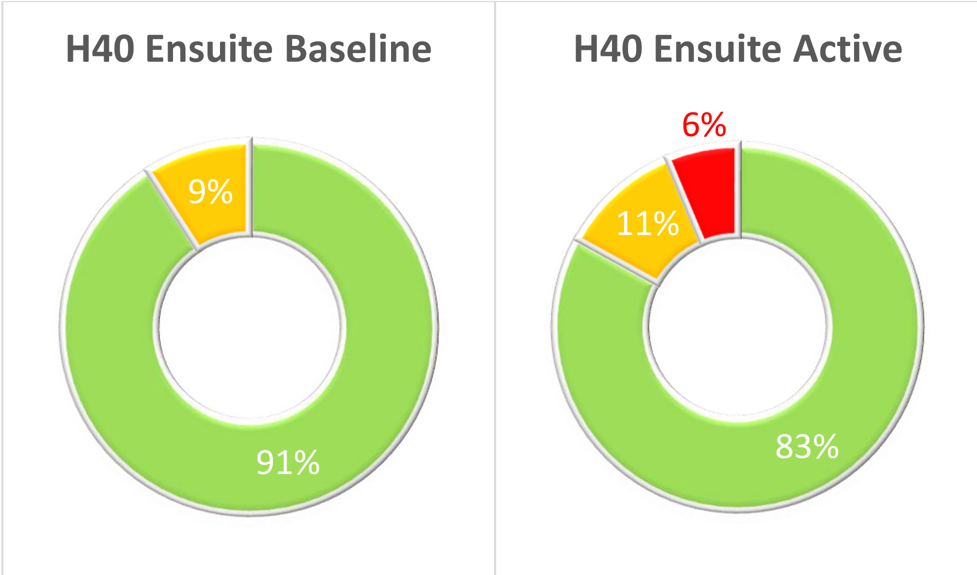


Figure 7-6. H40 Ensuite bathroom Baseline and Active shower durations by colour band.

7.3.3 H43

09/08/13 to 20/10/13

H43 live in a semi-detached house in Loughborough town. The family consists of H43MA and H43FA, and their teenage children H43mc and H43fc. The family are very social and creative, and showed a real curiosity about the device and how it worked. FA was openly worried about the device arriving, as she was conscious of enjoying long showers and didn't want to have to stop. On the other hand she was very keen for it to reduce the time the children spent in the shower as she felt it was excessive. The devices were installed in the main bathroom and in the parents' Ensuite bathroom.

As a family H43 are quite heavy energy consumers, there is lot of technology and lights around the house, and the focus is on enjoying life rather than policing energy consumption. Given this, the effect the device had on the teenagers was quite remarkable (see Figure 7-7). Both of them only used the main bathroom power shower, a while the parents used their own Ensuite bathroom (aside from a period between 25/07 and 10/08 when the Ensuite bathroom was broken and everyone used the main bathroom). Both found the device to be "really persuasive" and dramatically shortened their showers.

Mc had been the longest by all accounts and baseline data put his showers regularly above 15 minutes in duration. However within days of the device giving active feedback there was a significant reduction in showering durations. When questioned, he said that previously he often be aware that he'd have been in the shower for a long time but wouldn't have done anything about it. Interestingly though he reacted positively to the device, and dramatically shortened his showers, he had no negative feeling towards the imposition that the device had brought. Rather, he thought that it was a good thing and that it helped him to stop wasting water. His sister, fc, was also regularly showered for long times but had a more emotional and perhaps excited response to the device. She spoke of her reactions to it in very strong terms, mentioning fear and panic as responses to the feedback from the device. But also positive terms like how getting praise from the device made her feel good about herself.

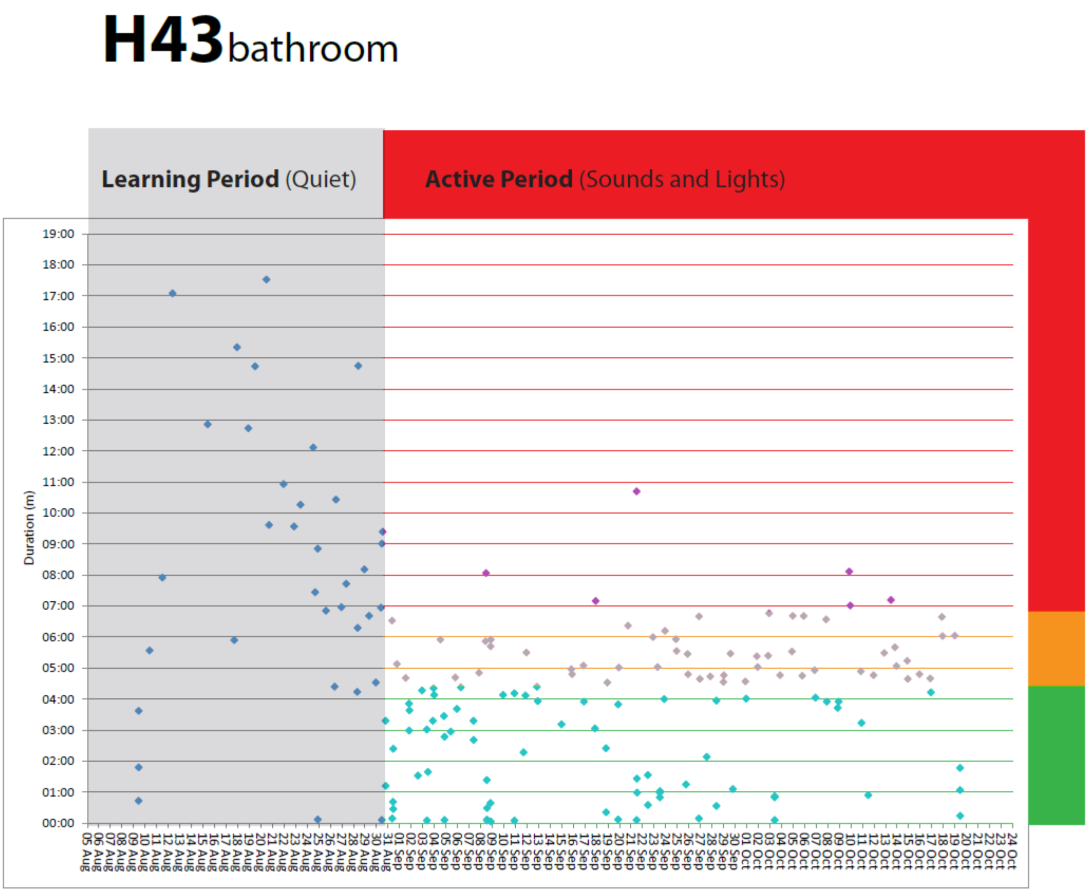


Figure 7-7. H43 bathroom intervention trial results.

The scale of reduction in this particular shower is clearly visible in the Figure 7-8, which shows the proportion of long showers to be dramatically reduced.

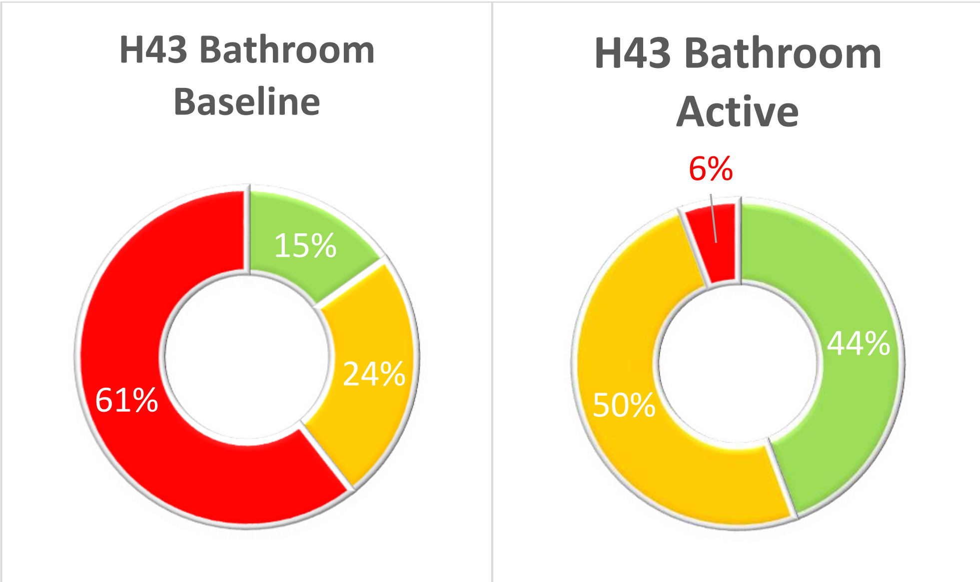


Figure 7-8. H43 Bathroom Baseline and Active shower durations by colour band.

FA had a strong affective relationship to showering, not only because she enjoyed the pleasurable aspect of routine showering, but also because she suffered from headaches brought on by a sensitivity to the cold which she treated with long hot showers. She was aware that she showered longer than might be considered reasonable, and was prepared to try to reduce this. She was particularly aware in terms of how her children showered for very long times, and wanted to play her part in reducing this. Like many of the users with an established longer showering routine, she found it near impossible to finish within the green section, but applied herself to finishing within the orange. This was a reduction in time for her as she would previously have been in the red section by and large. She was conscious, however, that the rest of the family seemed to be able to shower quicker than her, particularly her husband, who for a number of reasons was very quick in the shower. MA has a skin condition which is exacerbated by showering and so was already showering for the shortest time possible. Even though the device did not motivate him to reduce his times more, as he was already finishing within the green section, he developed affection for it both as company in the shower, but also because of the positive affirmation he received from it. As can be seen in Figure 7-9 , the device in H43's Ensuite bathroom stopped recording data on the 24/09/13 although it continued to give active feedback to the participants until the 19/10/13.

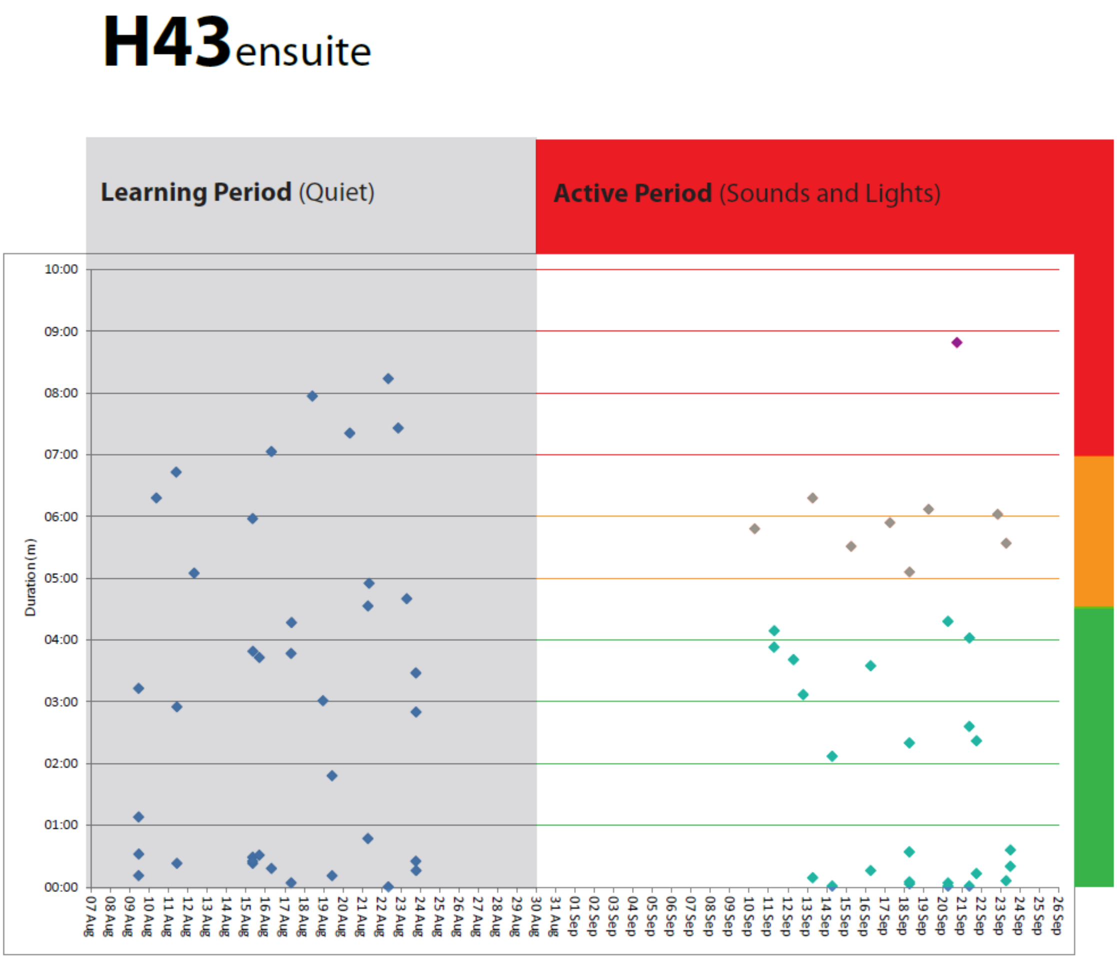


Figure 7-9. H43 Ensuite bathroom intervention trial results.

Figure 7-10 below shows this reduction in the number of longer showers across the period the device was recording. FA's efforts to "stay out of the red" are clearly visible, with sizable reduction in the number of showers over 7 mins.

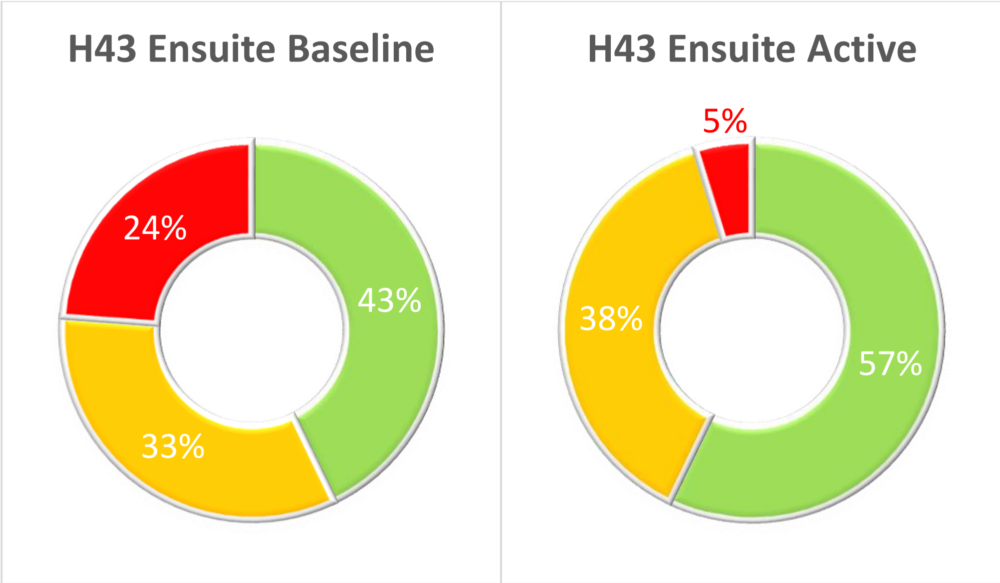


Figure 7-10. H43 Ensuite bathroom Baseline and Active shower durations by colour band.

7.3.4 H45

19/08/13 to 17/10/13

H45 live in a semi-detached house in Loughborough town. The household consists of H45FA and H45MA, and their son H45mc, with H45fc returning from university occasionally to visit. The house had two showers, one main bathroom used by mc and any visitors, and an Ensuite bathroom used by the parents. Prior to the arrival of the intervention, FA was very vocal about her trepidation in relation to the device. For her, showering was an extremely important pleasurable routine, using layers of products and pampering.

When the device arrived both males in the house quickly adjusted to the feedback and shifted from times in the low oranges, to being clearly within the green. The motivations behind this were slightly different for both. Mc referred to the transitions from green to orange in video game terminology as ‘levelling up’ and as a keen gamer he was motivated to avoid this penalty. Mc had in fact previously used YouTube songs played though his phone as a way of timing his showers, so was already keen to maximise his efficiency. This was less a motivation to do with saving water or other environmental factors, but more to do with freeing time for other activities.

MA had reduced to being within the green within a few days but continued to respond to the device for the duration of the trial. He found the segment beeps to be a useful prompt in terms of moving through his routine, though he admitted that receiving the same fanfare upon finishing every time became irritating over the course of the trial. Having said that, he expressed a sense of affection for the device and said he missed it when it was gone.

For FA as indicated, the relationship with the device was more fraught. For her, there was a strong conflict between enjoying her pleasurable existing routine and doing 'the right thing' as far as the device was concerned. Perhaps more than any other participant, FA made a concerted effort to find the optimum balancing point for her. Unprepared to give up using her body brush or range of products, she decided to stop brushing her teeth in the shower to gain an extra minute. This, combined with a reduction in the amount of time spent on the rest of her routine, allowed her to bring her times down to the orange section for the most part. She was very aware that while she was making this concerted effort to reduce her times to what she considered a reasonable length (within the orange section), that MA and mc were achieving green without the same dogged application.

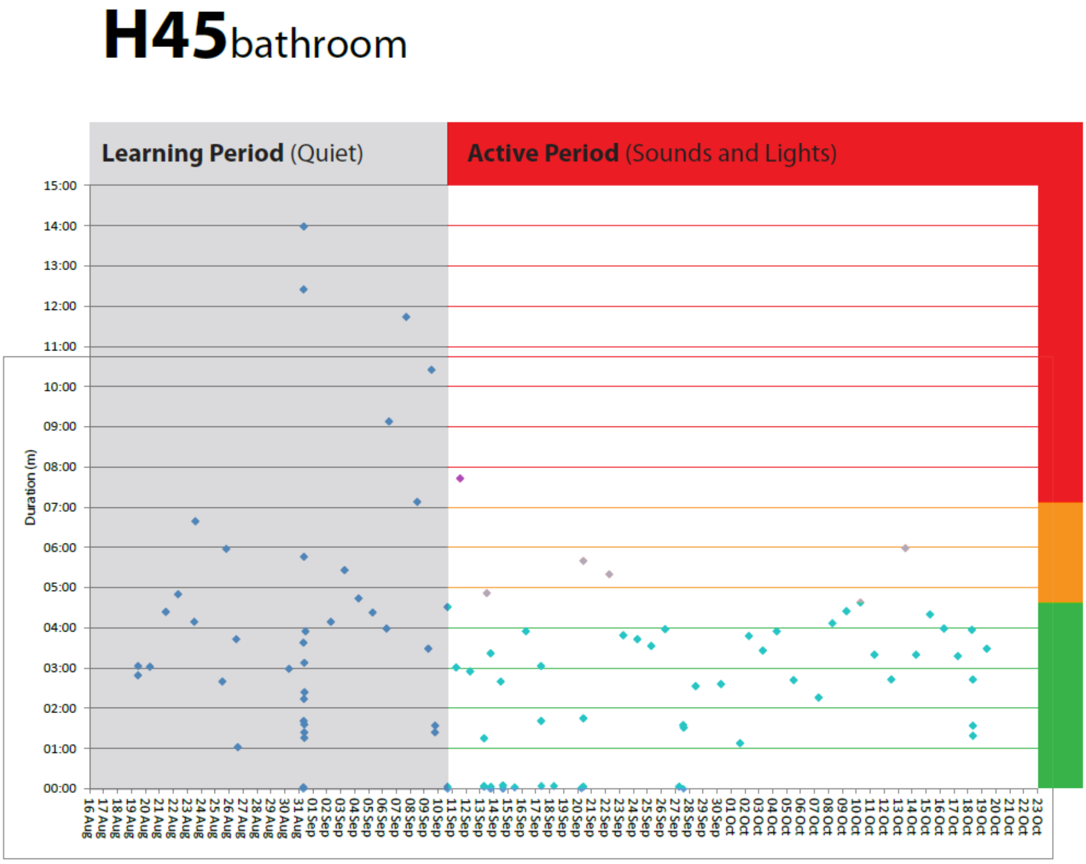


Figure 7-11. H45 Bathroom intervention trial results.

These results are clearly visible in Figure 7-11 above where mc, the primary user of the bathroom, can be seen to be regularly around five minutes before the device started giving feedback, which he reduced to be in the green section consistently thereafter. It's important to note that the high readings between Aug 30th and Sept 11th correspond to a visit from fc. This occurrence may have skewed the proportional change shown in Figure 7-12, below.

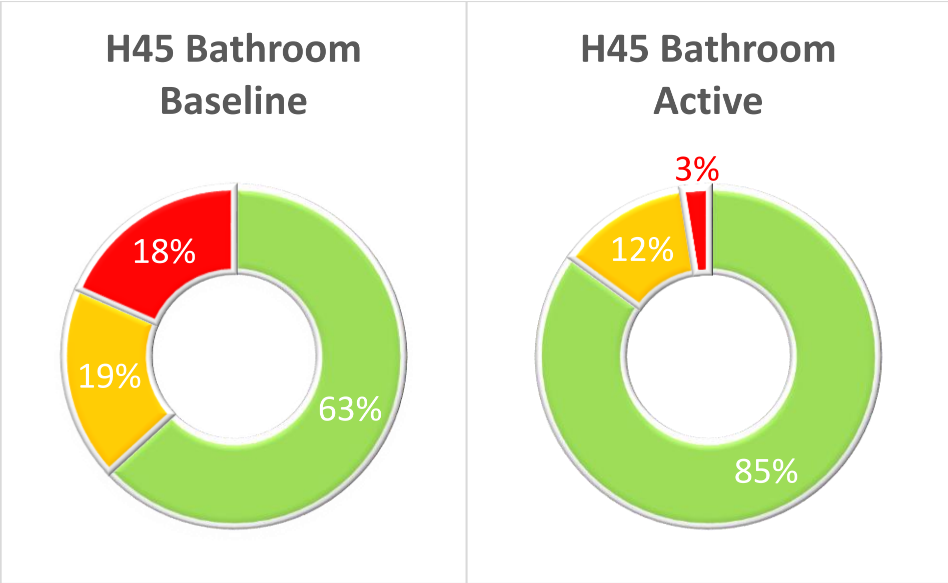


Figure 7-12. H45 Bathroom Baseline and Active shower durations by colour band.

The results from the parents' Ensuite bathroom in Figure 7-13 show two clear patterns of use, with MA's times being the lower band, which move from around five minutes to being within the greens. FA's results can be seen to be the higher band, moving from either side of nine minutes down to get into the upper end of the orange section.

H45ensuite

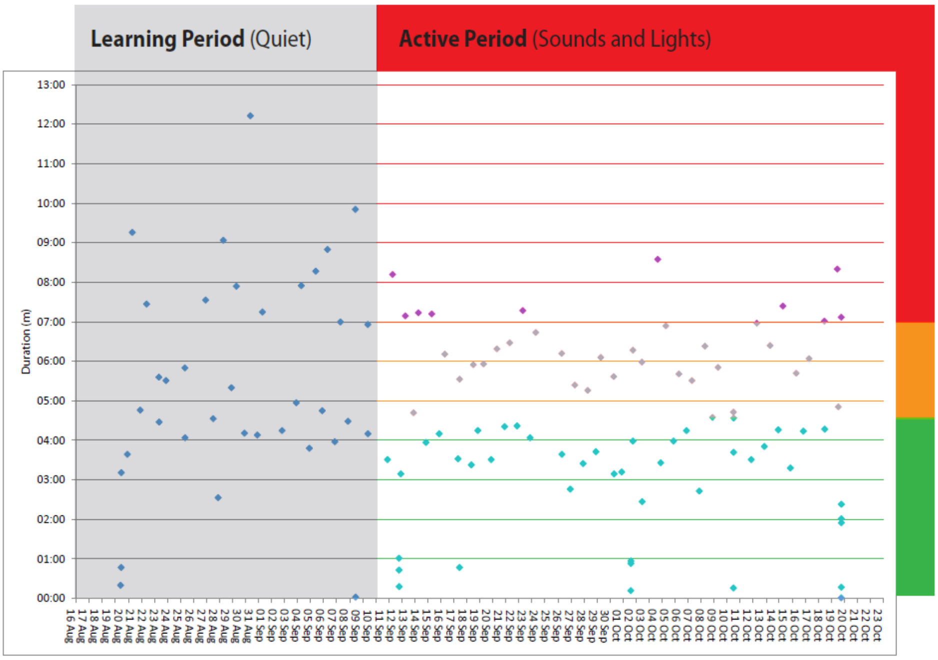


Figure 7-13. H45 Ensuite bathroom intervention trial results.

This down ward shift is visible in the proportional graphs shown in Figure 7-14 below, where a considerable reduction in the number of longer showers can be seen.

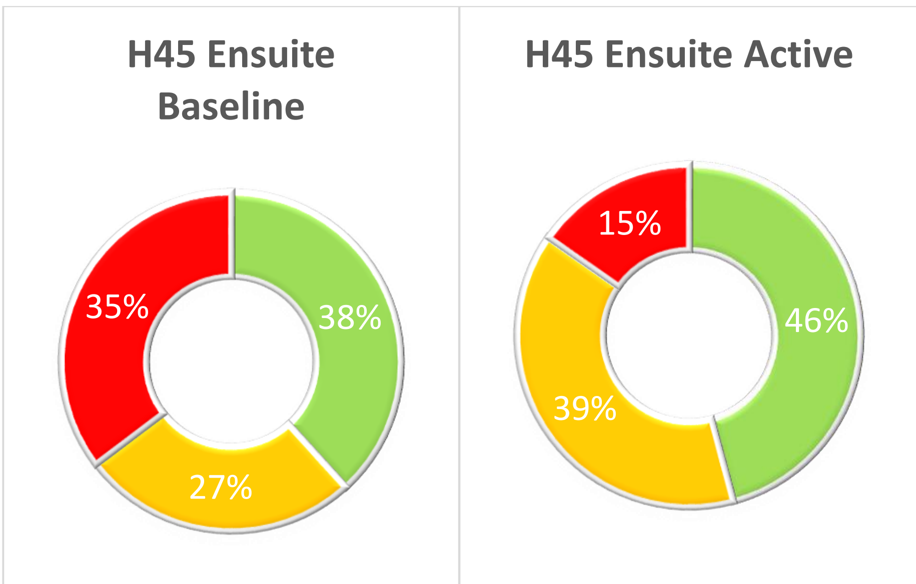


Figure 7-14. H45 Ensuite bathroom Baseline and Active shower durations by colour band.

7.3.5 H46

08/08/13 to 01/11/13

H46 live in a semi-detached house in Loughborough town. It is a very busy household, with three generations under one roof. There is H46MA and H46FA1, their four children H46mc1, H46mc2, H46fc and their new-born son H46mc3. Also living with them, in a semi-autonomous section of the house, is their grandmother H46FA2. All family members use the same bathroom but the two youngest children would more often be washed in the bath, and so would not have experienced the device. FA1, and the two youngest fc and mc3, were not present for the final interview and so any information giving about them was passed on through the other family members.

Perhaps in contrast to the majority of the participants of the trial, H46 have little interest in sustainability, and a busy family life is what tends to drive their behaviours rather than concerns of energy or cost. When the device arrived and started giving active feedback, mc1 and mc2 were very interested and excited. Similar to some other younger participants, they saw it being like a computer game and after having explored the different colours and sounds, tried to get a green score quite often. However, there were a number of occasions where the motivation to score in the green was overruled by a desire to have a longer shower. This is particularly true of mc1 who played football a couple of times a week and who enjoyed a longer shower afterwards. During these longer showers, he would sometimes get annoyed with the device for telling him that he'd done "something bad when he hadn't done anything bad".

MA described himself as very functional in the shower and tried to spend as little time as possible. Similarly, FA2 said she had a very paired back routine, and only spent as long as it would take to wash her body and hair. They reported that FA1 had a similar functional approach due to time constraints resulting from a busy family life. Interestingly, the adults did not speak of engaging with the device as much as some other households. This is perhaps because they were already fairly lean in their operations, but also perhaps because of a lack of motivation to save energy for either environmental or social reasons. Both MA and FA2 said they felt that the device had had no impact on their showering times, and that they just continued with the same routine as before.

In spite of this lack of motivational connection, the results indicate that the presence of the device and its feedback had a dramatic effect on showering times across the family as a whole. Prior to the active feedback, the vast majority of showering times were between four and eleven minutes. However, as can be seen in Figure 7-15, when the feedback started the majority of showers were within the green section (under 4.5 minutes).

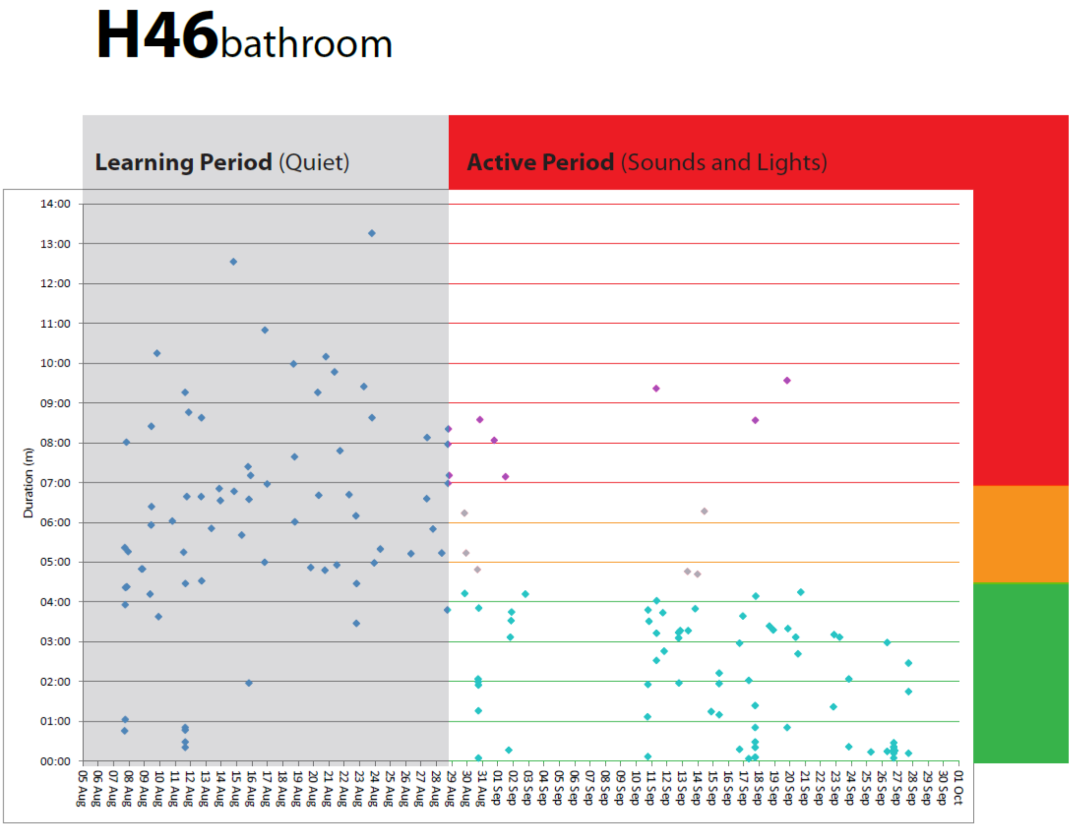


Figure 7-15. H46 bathroom intervention trial results.

The family were very surprised by this dramatic reduction in the length of showering times, as they hadn't been aware of it occurring. On questioning them further about it, MA felt that perhaps it was in part due to the 'water is hot' alert which had stopped him going and doing something else after turning on the showering until he was sure the water was warm. One other factor that may have skewed the data was that the family had taken to turning on the cold tap for a brief moment at the end of their shower to counteract the thermistor lag. However in multiple tests, this lag generally lasted between one or two segments, i.e. up to 90 seconds, which would not account for the significant reductions shown in Figure 7-16 below.

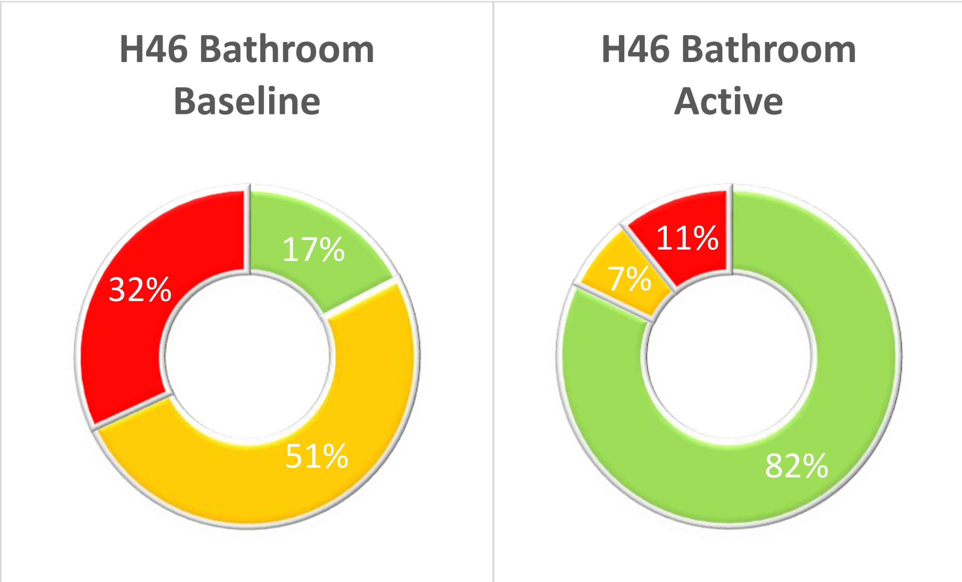


Figure 7-16. H46 Bathroom Baseline and Active shower durations by colour band.

This conflict between the family's own recounted assessment of the influence of the device, and the actual results is very interesting. It is quite possible that the results were due to a pre-attentive response to the feedback, but equally possible that this reduction was a more considered cognitive response to the feedback at the time of showering but one which was not fully remembered or explicitly communicated by, particularly, the adult participants.

7.3.6 H28

29/07/13 to 30/10/13

H28 live in a semi-detached house in Loughborough town. The family consists of H28MA and H28FA, and their two teenage children H28mc and H28fc. They have one bathroom that the family all share. The trial in this household highlighted a significant design flaw in the intervention device, which was that the triggering of the device was set at a specific water temperature, 35°C. This temperature was chosen as it was believed to be 5°C lower than the average showering temperature. However, almost the entire family in H28 had a preference for showering with a water temperature of around 35°C. The natural slight variations in temperature produced by the electric shower in this house, caused the water to fluctuate either side 35°C, thereby triggering the device on and off multiple times during the duration of a single shower. In real terms, this often meant that in the course of a single shower, participants would receive multiple fanfares for having 'finished' within the green section.

Obviously, this level of sustained malfunction provided a significant barrier to any engagement the participants might have experienced with the device, and also rendered the quantitative results meaningless. As can be seen in Figure 7-17 below, there are a huge number of very short events (<1 minute), which negate any pattern that might otherwise have been visible. As a result, the data and feedback from participants in H28 has not been used in the rest of the evaluation of cogitative and emotional engagement with the device. The exception to this is the very clear requirement for any future such intervention to function reliably at lower temperatures.

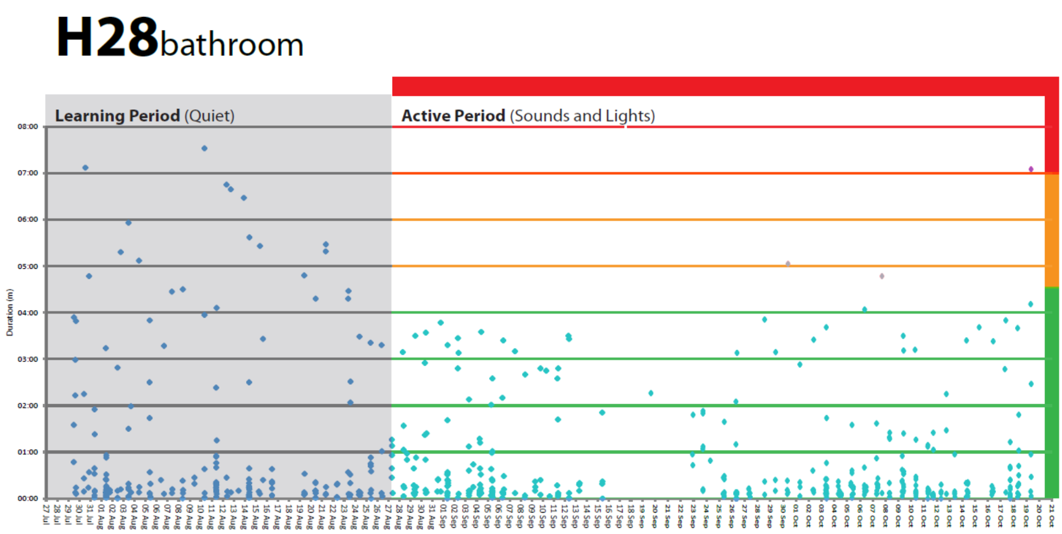


Figure 7-17. H28 bathroom intervention trial results.

7.4 Discussion

7.4.1 Introduction

This section will discuss the results of the intervention trial placing them in the larger context of this research.

This research sits firmly within the field of Design for Sustainable Behaviour (DfSB), this section will also discuss the success of the intervention against the criteria laid out in Wilson's (2013) comprehensive DfSB evaluation. This, it is hoped, will show the relevance of the conceptual model and the Behavioural Intervention Selection Axis to the field of DfSB.

This section brings in considerably more qualitative findings than included in the Results and Findings (section 7.3). This is because the vast quantity of responses gleaned from the six interviews with the participating families is difficult to present in a meaningful fashion without embedding it in the theoretical framework which gave rise to the intervention. As such, this section both presents results and discusses them simultaneously.

7.4.2 Design for Sustainable Behaviour Evaluation

This section will evaluate the effect of the intervention against Wilson's (2013) DfSB evaluation criteria. This is currently the most comprehensive and recent evaluation criteria in the field and can be summarised in three simple questions:

- Did the produced design solution function for the specified context?
- Has the User's Behaviour Changed as a Consequence of the Design Intervention?
- Is the Change in the User's Behaviour Sustainable?

Each of these questions addresses a core component of DfSB theory, and each has been broken down into a number of sub-question, which explore the results against established theories.

Did the produced design solution function for the specified context?

How frequently and what is the duration of the feedback information that is fed back to the user?

The duration of the feedback information that is fed back to the user is the full length of the operation. The frequency is at every operation. The effect this has on the user's cognitive bridging between action and effect is that of clarity. All users found the delivery of feedback information to be clear and easy to understand.

> *"Did the way unit worked make sense to you, the different colours?"* ***Interviewer***
> *"Those colours, we're very used to those colours are we, and we respond to them."* ***H45F***

The feedback is presented to the user with every shower for the duration of every shower. The device is located by the shower controls and comes to life when the water has been turned on and has reached temperature. This proximity and automatic live feedback led all users to understand that the feedback was directly relating to the duration of their shower.

> *"I was very persuaded to have a* really quick shower*! [Laughter] The first time I was in there I literally went half way through the green, and then I got back out again! I was really scared that it would, like, really beep at me or something if I got to yellow! [Laughter]"* ***H43fc***

How accurate is the feedback information presented, and how does this help to associate or dissociate a user with their actions?

As the feedback is given live and in the context of operation, the users were clearly able to associate the consequences of their actions with the progressively negative feedback from the device. However, due to some technical limitations of the prototype, there was often some time lag between the shower being turned off and the device recognising that the flow had stopped. In some cases this would have led to the device continuing to count the duration of the shower and going up into the next one or two segments. This became an issue for some users as they felt cheated that they had finished within a target time but that the device had not recognised their effort and had played a finishing sound corresponding to a longer shower duration.

> *"[Laughter] Yeah, there was one time I got out of the shower in the green and it turned to orange! I thought how can this be?! I started blowing on it, and wafting it around! [Laughter] and then I realised that if you turned the cold tap it stops! [Laughter] Did you not do that too?!"* ***H43FA***
> *"I do that! [Laughter]"* ***H43mc*** *and* ***H43fc***
> *"I felt cheated when I've done so well!"* ***H43FA***

Interestingly, this lack of accuracy may actually have increased the users' motivation to 'beat the machine' or to find other hacks and ways around this. This will be discussed further in section 9.3.7.

How does the selection of the contents and metrics resonate with the user's individual norms and motives?

As outlined in Chapter 6, the device sought only to reduce the duration of showers to an acceptable level. As such, the metric chosen was time rather than for example kW or Litres. This metric was very clearly understood by all users as it is a very human concept and one we deal in every day. And for some users the availability of this metric was considered a real plus, not just in terms of the impact on showering, but in giving them a sense of time relative to the rest of their day. For example, knowing how long they had been in the shower if they were rushing to leave the house.

> But mainly it think it's just the device being there, it acts as a reminder, reminding you how long you've been standing there. And you think "well the longer I'm standing here the more water, the more electricity I'm

> using". It gives you a sense to try and reduce that. And having had it taken out, I've missed it a bit." ***H45MA***
>
> "Why is that?" ***Interviewer***
>
> "Well it's certainly not the sounds. I don't miss them. No, I think it's the sense of time it gave me." ***H45MA***

While the metric was successful within the context of the act of showering, several participants commented that they would have liked to have seen a cost-based metric or a litres of water metric. This comment reflects the values expressed in the GTKY but was technically unachievable within this prototype. Furthermore, given that the cost of showering would generally be measured in pence as opposed to pounds, live feedback of this may not be as motivating as envisioned.

> "I think you need to show them what this shower cost you say, for 4 mins its 40p, for 7 mins its 70p. And then you can add up what it costs over time and what else you could do with that money, and I think women in particular would be swayed by that. Not even the cost to as the people paying for water and electricity, but the cost to the environment as well." ***H45FA***

Is the feedback information presented as a granulation from a larger system, and how does it help or hinder a user's understanding of this information within that system?

While the feedback device does not give any information relating to the larger energy systems as a whole, this is an intentional design feature which recognises the nature of situational behaviours, like showering. Users do not tend to show the mental capacity or interest in understanding a wider more complex system while they are trying to achieve a specific task. Because of this, the device only provides feedback and information on the specific task being undertaken at that time and in that context.

How does the medium of presentation affect a user's ability to engage with the feedback information?

As the device's feedback was presented in the shower itself, there were a number of strong contextual barriers it had to contend with. The shower is often a relatively noisy space, due to water pumps and the sound of water splashing. In addition, because of the flow of water, the user often has their eyes closed or their back turned on the device. The device sought to overcome this by using an illuminated graphical display featuring traffic light colour codes, and a large dynamically changing display of consumption. While this strong graphic format allowed for near instantaneous comprehension by the participants, it did not solve the issues of them looking in a different direction or having their eyes closed. To address this, the device used a range of audio alerts, from segment beeps after every 45 seconds, to longer and louder klaxon alerts at the transition from one section to the next, e.g. green to orange. This dual system of feedback proved very effective, with a number of participants commenting to that effect.

> "To be honest, the fact that you can see it and hear it makes it more effective." ***H45FA***

How does the selection of presentation mode affect the user's comprehension of the feedback information provided?

The feedback device utilises a dynamic visual display composed of 6 segmented LED panels. The medium of information, in colour-coded indicators and progressive sound alerts, is designed for instant comprehension during the act of showering.

As the main metric was time, a concept relevant to all of our participants (unlike for example kWh or BTU), the comprehension of the feedback was extremely high. In addition, the presentation mode of using traffic light colour codes and progressively more unpleasant sounds, was clearly understood by all participants.

> *"Yeah I think, was it? No, no Marcus it was the long beeps as well I noticed that and oh I haven't heard that before. I mean I haven't heard that before, oh I'm obviously doing something different here. I'm not surprised because I'm here for a long time."* ***H37MA***

How does the user interpret ambient features, and to what extent are they cognitively mapped by the user and in line with the designer's intent?

The ambient features of the device primarily consist of the LED display panel. This panel progressively fills up as the user moves through the time sections within that phase, e.g. green, orange or red. These colours were chosen for their association with traffic lights and a number of other visual representation systems which echo it. The colours and their import were clearly understood by all users because of this association.

> *"Did the way unit worked make sense to you, the different colours?"* **Interviewer**
> *"Those colours, we're very used to those colours are we, and we respond to them."* **H45FA**

A secondary effect of the ambient features was evidenced by a couple of participants, both males who generally finished in the green segment, and that was its atmospheric quality in the bathroom. They stated that the ambient aspects of the feedback actually enhanced their showering experience.

How does the location of the device affect the ways in which the user interacts with the feedback information?

As the unit was located within the shower, the primary interaction of the users was with it while actually showering. Within the shower itself, the placement of the unit did have an effect on its visibility and the amount of interfacing the user undertook.

However, as the device was in a static position and thus oriented in a fixed direction, generally beside the shower controls, many users commented that while showering they would turn their back to the shower head and controls, to keep the water stream out of their eyes. Because of this, they would no longer be paying attention to the visual display. However, the audio prompts worked regardless of the orientation of the user, and would often cause them to turn and check the visual feedback to see what stage they were at.

> *"One thing I would say is that when you're standing in the shower you tend to stand with your back to it, so it is possible to ignore it. Like, when our unit started failing and I couldn't hear the noises." H43FA*
> *"It gives a beep every section which just reminds you that it's still there."* ***H43fc***

While the primary interaction with the device took place in the shower by the person showering, the volume of the alerts and finishing sounds could often be heard in the adjacent rooms of the house. As such, some participants reported being able to hear how long other family members had been in the shower, particularly if the finishing sound was considered note-worthy, e.g. a green fanfare or a red noise. This can be considers a form of social reinforcement and in some cases would have led to further discussion.

> *"I could hear, cus my brother, when I'm getting ready for bed, I can hear him having a shower. And I can actually listen to the noise at the end of his shower and I can determine what level he's gotten."* ***H43fc***
> *"That's exactly what I did with you [H43FA] a couple times, cus I'd make a comment when you got out."*
> ***H43MA***
> *"A snidey comment probably! [Laughter] When I was in too long!"* ***H43FA***

The downside of the situated nature and transient quality of the feedback, was that it could not be examined or interrogated by interested users at a removed time or place.

> *"Like FA says, it depends whether you're bored or not. No I think if it was on there, and I had bought it, I would take some interest in the stats. I like stats, I'm a stat person."* ***H43MA***
> *"If it, like, saved all of the data."* ***H43fc***

"Or it showed you in monetary terms, how much you were chucking down the drain." ***H43FA***

Has the User's Behaviour Changed as a Consequence of the Design Intervention?

The second of Wilson's (2013) evaluation criteria relates to changes in the users' behaviour, e.g. has this design intervention caused them to behave in a different way to how they did prior to its introduction. This is obviously an extremely central question, and has to some degree already been answered in previous sections which have recounted varying degrees of behaviour change from the participants. However, the origin of the questions making up this criterion lies in Triandis' Theory of Interpersonal Behaviour, which differs somewhat from the goal frame theory guiding this research. As such, there are some areas Wilson pursues that were not covered by this research in explicit terms. Given this, this section will discuss the intervention's effect on the users behaviour in general terms rather than answering the specific sub-sections of Wilson's criteria. These original questions will be placed into meaningful groups and shown alongside the relevant passages.

Reflective Attributes

2.1 What was/is the user's knowledge and perception of environmental matters, morality, resource consumption and comfort, both prior and post to the introduction of the design intervention?
2.2 What was/is the user's value weighting of environmental matters, morality, resource consumption and comfort benefit, against expected cost, prior/post to the introduction of the design intervention?
2.3 What was/is the user's conceptualisation of social rules and actions relating to environmental matters, morality, resource consumption and comfort both prior and post to the introduction of the design intervention?
2.4 What was/is the user's categorisation of social and group roles in terms of environmental matters, morality, resource consumption and comfort, both prior and post to the introduction of the design intervention?
2.5 What was/is the user's perception of their self and what do they deem to be appropriate goals and actions in terms of environmental matters, morality, resource consumption and comfort, both prior and post to the introduction of the design intervention?
2.6 What are the positive and negative emotional responses associated with actions related to environmental matters, morality, resource consumption and comfort, both prior and post to the introduction of the design intervention?

Contrary to some understandings of behavioural psychology, the participants did not seem to have changed their attitudes, values or norms relating to showering from before to after the trial. Indeed showering, given its largely situational nature, was not something the participants had thought about that much at all. Any awareness of the environmental impact of showering was generally of its efficient nature in comparison to baths.

> *"I thought about how much water was being used, because I remember John Noakes standing in the shower in 1976 when there was a drought, talking about how much difference there was between a shower and a bath. Alright Im a bit older! But I didn't equate it to power usage, even though I know from the light dimming that the 5kW makes a massive draw on, but I didn't reflect on it much."* **H43MA**

The participants exhibited almost no concern about social rules relating to showering, with the exception of H37MA who had a very strong moral view on waste.

> *"And I really don't like doing that you know I really have a real dislike for any kind of wastage you know especially water when you know there's people on the planet who could really do with it so I really don't like that sort of wastage so that was, that was great."* **H37MA**

The primary concern of the participants was that of cost, e.g. how much money showering cost them, and how much if any they could save.

> *"It would just be nice to know that showers weren't costing as much as they have been."* **H37FA**

While cost was mentioned as the main motivator, many participants qualified this by saying that comfort was a stronger motivation, and that a reduction in cost alone might not necessarily get them to change their behaviours.

> *"And would the information about the cost of showering have motivated you? Where it says, the average family spends over £400 a year?"* ***Interviewer***
> *"No, not really…"* ***H43FA***
> *"It's more of a pleasure for you?" Interviewer*
> *"Yeah, I like to be warm, in the winter especially, I suffer from headaches and the shower is the way I get warm and relax."* ***H43FA***

Further to this, when the trial was over and the participants were shown their results in graph form, the vast majority of them said that they would consider using a similar device in function in future if it could provide clear financial savings.

That there was not a dramatic shift in participants' attitudes, values and norms over the course of the trial, even those participants who effected significant reductions in their consumption, demonstrates the situational nature of the target behaviour. Any success the intervention had in changing this behaviour, as discussed in the previous section, was due to it acting in context at the right time. It did not give root to broader social awareness because the behavioural situation did not warrant it.

Furthermore, it is believed that it is not necessary for a design intervention to significantly change a user's attitudes, values or norms relating to environmental matters in order for it to change their behaviour. As demonstrated in section 9.3.7, a design intervention can become a new actor in the behavioural sphere, eliciting a broad range of behavioural responses without changing these attributes.

Situational Attributes

This part of the evaluation seeks to determine the level of automaticity of the target behaviour. It is derived largely from Verplanken's (2006) definition of habit. This definition of habit shares a great deal with the definition of situational behaviour used in this research. Indeed, the concept of situational behaviour is largely based on that of habit but with a broader, less rigid criteria. This less rigid criteria allows behaviours, which might not be considered fully established habits under Verplanken's definition, to be viewed as having a level of context-driven automaticity, a key concern for intervention development.

How frequently was/is the behavioural act enacted, prior/post to the introduction of the design intervention?

For most participants, showering is a daily occurrence, which by and large fits into larger and established routines. Activities like sports, cycling, and school and work all generally had an effect on when the activity occurred.

> *"I do it first thing in the morning, get up, walk dog, H45MA's gone when I get home and jump into shower. It's quite a ritual, a routine."* ***H45FA***

Only one participant actively avoided showering, due to a skin condition.

> *"I shower every morning, and the odd evening if I've a headache. Or if I've been out walking the dog. H43MA has psoriasis and because of the hard water he doesn't tend to shower as often as we do. I'll use once to twice a day, the kids every day, and Martin would be 2-3 time a week."* ***H43FA***

Some of those who showered daily reported varying shower practices depending on different factors. For example, many female participants reported only washing their hair some of the time, while other participants talked of having considerably longer showers after being outside playing sports, or just feeling cold in general.

"Kind of and kind of not. But I wash my hair as well but it's kind of a bit random because I have PE and I have to tie my hair up to the end?" ***H40fc***
"I think for both H40fc and I, you know you we have long hair it's all down to time as well." ***H40FA***
"Yeah, and I always wash my hair on a Saturday which I just did now because I've been swimming in the morning." ***H40fc***

While the intervention had a visible effect on the durations of the participants' showers, it did not seem to alter the frequency. This is an important consideration to note, as it indicates the effect of the intervention was only prominent while they were showering, as opposed to being something they considered off-putting.

Did/Does the user exhibit a lack of awareness of how they act in terms of conscious decision making or delegation of control of the behavioural act to contextual cues, prior/post to the introduction of the design intervention?

The shower can be a 'timeless place' where the primary task of washing is often not the users' full focus. It is a behavioural space that allows for day-dreaming and drifting off, as well as a host of time-consuming grooming rituals, e.g. shaving, washing hair, back scrubbing etc. Prior to the introduction of the intervention, most participants reported a lack of awareness of time spent in the shower, and even of their actions during showering.

"In the mornings it's a part waking up, and in the evening, in the winter, it's part of warming up and relaxing. I just like the shower!" ***H43FA***
"And would guys be similar." ***Interviewer***
"Yeah, It's a way to unwind really." ***H43mc***

"I'd just think "oh I must have been in there a while" but, no, you've absolutely no concept of time when you're in a shower." ***H43FA***

The introduction of the device acted to refocus the participants' attention on the primary task. For those participants whose functional shower routine was relatively short, the intervention interrupted their day-dreaming and spurred them on to the next task in hand.

> *"And did that become more pressured with the device beeping?"* **Interviewer**
> *"No, it just made you realise how long you spent day dreaming in the shower and just wasting time doing nothing."* **H43FA**

However for those with a longer functional shower routine, e.g. washing and conditioning hair, shaving legs etc., the intervention, when successful, prompted them to speed up and complete their routine at a quicker pace.

> *"Yeah, when I got to two yellows, I'd go "right that's it!". Even if was in the middle of washing my hair, which never happened, I have just got out."* **H43fc**

> *"Well yeah, to begin with but you get used to it in that shower and you start to feel quite smug if you got between a certain time. And from time to time I certainly try and reduce the time I spent in there by changing things like not brushing my teeth in the shower so you get used to it."* **H45FA**
> *"So you did change some aspects of your behaviour?"* Interviewer
> *"Definitely, yeah."* **H45FA**

Did/Does the user have free mental capacity to do other things, or exhibit efficiency through expectation filters, prior/post to the introduction of the design intervention?

In some regards, showering is an almost incidental behaviour, in that the act of turning on the water, the element of the behaviour with the largest environmental impact, can be somewhat removed from the other activities that are undertaken. The participants reported doing a host of time-consuming grooming rituals, e.g. shaving, washing hair, back scrubbing etc. while in the shower. In addition, some participants also reported using external media such as iPads or smart phones to play music while in the shower.

> *"And again when you are using it you think there are ways that you could speed up?"* **Interviewer**
> *"I don't think so, the main thing for me is when I am in the shower and I do my shaving, as well, so I am conscious of the flow of water constantly and I think well should I do that somewhere else, in a bowl or something but then it's so messy and awkward and I think no I wouldn't bother doing that."* **H40FA**

> *"H37fc1 does that, yeah. She'll put on the radio or something on her phone. Sometimes you take the iPad in there; father doesn't need to know that."* **H37FA**

While it is difficult to determine what aspects of these behaviours are secondary to the act of showering, and what actually constitute it, there were other behaviours spoken of which clearly are not related to the act of washing. For example, many of the participants would switch on the shower and walk off to do something else while they waited for the water to get warm. As they were away from the water, it is likely that they could not accurately tell when it was ready to get into, and that warm water was being wasted.

> *"Occasionally as I say especially if I get up if it's in the summer and the heating system isn't on, I'll turn it on and yes I might walk back into the bedroom and grab some clothes or something, even maybe go and see one of the girls and then come back and get my shower but that's unusual to do that."* **H37MA**

This was one aspect which the intervention was successful in targeting with a number of participants commenting on how it refocused their attention on the flow of water.

Did/Does the user have difficulty in controlling their behaviour in relation to this act, with trouble in deliberate thinking or planning, prior/post to the introduction of the design intervention?

The primary issue put forward by most of the participants was that of the shower being a timeless space. It is a closed and private area which allows users to drift away into their own thoughts, often in the process of fully waking up. Day-dreaming was mentioned by several participants, as was processing thoughts from the day. While this introspection is facilitated by the private nature of the space, it is further supported by being in a warm, pleasurable environment.

> *"Not really pampering, but yes I supposed it was relaxing. You know it was 9 times out of 10, any time I get to myself without them "Mommy" I just can't hear them in the shower. So I supposed it was relaxing time."* ***H37FA***

Even very efficient users, who were highly motivated by time efficiency, reported being brought back to themselves by the sound alerts indicating that they too had drifting off, albeit for a shorter period.

Did/Does the behavioural action represent a sense of personal identity to the user, prior/post to the introduction of the design intervention?

Beyond just drifting off, for some female users the shower was considered a highly pleasurable environment for pampering and grooming. In a couple of cases, this would have been considered one of their most pleasurable, and even necessary, escapes. And the users were extremely conflicted and challenged to try and reduce time spent in the shower.

> *"I'd have to completely change how I felt about the using shower. I'd have to take out the body brush, I'd have to get rid of the conditioner because that takes time too, and face wash. So I'd have to really change everything."* ***H45FA***
> *"Would you want to?"* ***Interviewer***
> *"No!"* ***H45FA***

Is the Change in the User's Behaviour Sustainable?

What was/is the domiciles domestic energy consumption prior/post to the introduction of the design intervention?

Within the specific context of the intervention, the participant's energy consumption or water usage was not measured as a whole prior to the study. This is due to a large degree of complexity and variance in the sample, and the technical issues that come with such disaggregation. However, for the first three weeks of the trial the feedback device was installed without sound or visual display, to record a baseline of usage. This allowed the collection of a relevant metric, in this case duration, with which to compare the active phase of the device, i.e. when it gave visual and audio feedback. Rather than communicate these durations in terms of averages or ranges, it is considered more useful to provide a visual display of the effect of the device on showering durations over time. As such, graphs were produced to provide a clear indication of the effect the device had on the duration of the participants' showers and thus the related energy consumption. These graphs with additional information about the relevant households can be found at the beginning of this chapter, in the summary of results by family.

Disregarding the results of H28 due to the unreliability displayed by the device, in the remaining five houses we see a fairly wide range of impact on energy consumption. In H40 there is no visible sign that the device caused the participants to reduce their showering times in any sense, if anything there is a trend towards increased consumption. As qualified by that segment, the device did not map well with the household's varied showering practices, and it is unclear whether this is actually an increase, or the result of unaccounted showering practices, e.g. leaving the shower running or more than one person showering at a time. In the remaining four households, there was a consistency to the results, which makes them appear more credible. In all four households we see a reduction in the amount of showers longer than 7.5 minutes. This ranges from a slight apparent reduction, as in the case of H37, to a very dramatic reduction, as in the case of the main bathroom in H43. Taken as a whole, we can average out the percentage of showers falling in to each colour band. Figure 7-18 shows the percentage of all showers in each colour band during the baseline and during the active intervention period.

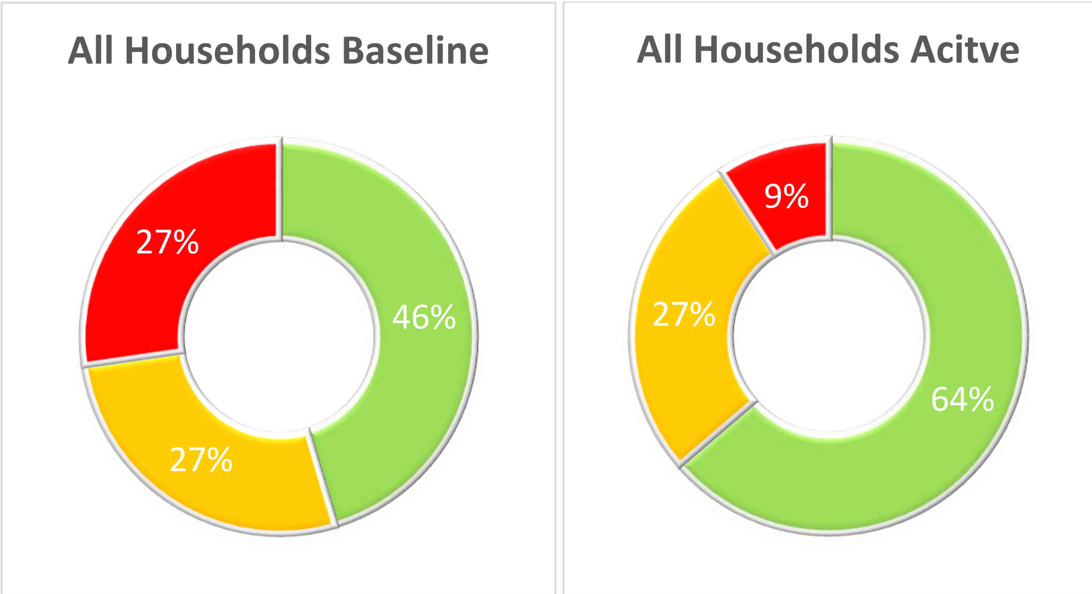


Figure 7-18. All households average Baseline and Active shower durations by colour band.

As the intervention was designed to reduce the occurrence of long showers, rather than shorten all showers, an overall reduction in durations does not necessarily indicate its success. Rather, a reduction in the number of longer showers would indicate that the device achieved its objective. This can be clearly seen in the reduction in over all percentage of showers longer that 7.5 minutes from 27% to 9%.

What was/is the domestic energy consumption by inhabitant/appliance/room/temporality prior/post to the introduction of the design intervention?

While it is not possible to discern from the recorded data the nature and duration of every individuals showering regime, the plotted graphs were used in conjunction with the qualitative interviews to assign patterns and events to particular users in some cases. This was mainly possible where there was a low number of users of a particular shower and where both users had reported regularly gaining significantly different levels. See for example H43, H45 and H37 on the graphs in the summary of results by family at the start of this chapter.

Moreover, many of the participants reported a common pattern of usage which could be roughly extrapolated from the data sets during the interviews. As such, we can say with a reasonable degree of accuracy that in some cases it is quite clear how the participant has reduced the duration of their showers over the course of the trial.

What were/are the inhabitant's expectations and actual levels of physical (lighting/acoustical/air/thermal) comfort, prior/post to the introduction of the design intervention?

In the context of showering, physical comfort is composed of a number of variables. Most obviously the flow rate and temperature of the water, the duration of the shower itself, as well as the acoustic and lighting elements of the process. While the flow rate and temperature obviously have a very significant environmental impact, they were not measured or altered by the intervention itself, and all participants confirmed keeping those settings the same as prior to the trial. The intervention obviously sought to impact upon the duration of the showers as well as altering the lighting and acoustical aspects of the experience, and these will be discussed below. In order to give a meaningful answer across the entire sample, it is necessary to group the participants' responses into broad categories.

Perhaps the most useful distinction is to separate the participants into those with shorter shower routines, e.g. finished in the green section, and those who regularly took longer. For the more efficient users, showering, while not displeasing, was a fairly functional task. These users did not seek the sensory pleasure of a long hot shower, and their expectations of comfort can be said to be relatively low prior to the installation of the intervention. For these users, the arrival of the intervention more often than not seemed to increase their acoustic and lighting comfort through the introduction of positive noises and the ambient glow of the device. As comfort is a subjective measurement, this apparent increase in acoustic and lighting comfort must be seen in the context of these users regularly receiving positive affirmation from the device. It should be noted that the acoustic aspect seemed to weaken with time, as the noises remained the same, and became less pleasing for those users who regularly finished in the green section.

On the other end of the scale, a number of participants had a very high expectation and association of comfort with showering. In this sample, these were all female participants, teenagers and older. Showering was a notably pleasant activity involving a degree of pampering and grooming and tied into larger notions of self-image. Regardless of whether they were motivated to shower more quickly or not, these users had longer routines involving more steps, e.g. shaving, washing and conditioning hair, body scrubs etc. These longer routines naturally pushed them into the orange and red sections of the device's feedback scale, with the ensuing unpleasant audio and visual feedback. These types of feedback combined with a sense of pressure and even guilt to make the experience more uncomfortable for these participants. In addition for many it was the first time that they had seen an accurate reflection of the duration of their showers, which many acknowledged to be excessive. However, while the intervention may have effected their expectations of comfort while it was in place, it seems these users went back to enjoying longer showers after its removal.

What was/is the domestic comfort level by inhabitant/room/temporality prior/post to the introduction of the design intervention?

This question cannot be answered satisfactorily with the data available, but an indication may be provided by the previous answer above.

Can the effect of contextual infrastructure (such as building fabric, situational context and economic variables such as cost per unit of energy etc.) upon energy use and comfort, both prior and post to the introduction of the design intervention, be quantified?

Across the sample, over the duration of the trial, there were no notable changes to these factors as far as could be determined. Given the relatively short duration of the trial, it is impossible to quantify the impact of the factors, if any.

Does the ecological, economic and social benefit from the change in behaviour outweigh the ecological, economic and social impact of intervention provision?

Given that the device was tested in prototype form, requiring large batteries and over a short duration, its ecological and economic impact versus the visible gains are perhaps unclear. However, it is likely that a production-ready version of the feedback device, as proposed in section 9.5 would utilise a turbine to generate its own power. This would leave just the economic cost and the ecological impact of the embodied materials to compare against the potential reductions incurred by changes in the users' behaviour. Thus if we take the results of the trial to be indicative of a broader and more prolonged deployment of such a device, we can roughly extrapolate out the potential impact over 5 years.

Two examples from the study have been processed to evaluate the potential impact the intervention could achieve in a year in Table 7-1 and 7-2. The examples chosen are at different ends of the scale in terms of the reduction achieved by the participants. This is intended to give an indication of the variance shown in a small sample of six families. These results are purely indicative and cannot be viewed as having any statistical relevance.

Table 7-1. H43 Bathroom Consumption Data.

H43 – Bathroom	
Flow rate	15 litres/minute
Average Baseline Shower duration (excluding events <1 minute in duration)	9 minutes 18 seconds
Average Baseline Shower water volume	137.7 litres
Average Shower duration with Intervention	4 minutes 16 seconds
Average Shower water volume with Intervention	62.4 litres
Net saving per shower	75.3 litres per shower
Saving in energy input to heat water (Assumption = water is heated from 16°C to 40°C, Heat added = specific heat x mass x (tfinal - tinitial))	2.1017736 kWh per shower
Annual Energy Saving (Assumption 650 showers p/a between two primary users)	1366.15284 kWh
Annual Water Saving	48945 litres
Annual cost saving (Gas@7pence/kWh)	£95.63

Table 7-2. H37 Ensuite bathroom Consumption Data.

H37 – Ensuite bathroom	
Flow rate	10 litres/minute
Average Baseline Shower duration (excluding events <1 minute in duration)	5 minutes 2 seconds
Average Baseline Shower water volume	50.3 litres
Average Shower duration with Intervention	4 minutes 39 seconds
Average Shower water volume with Intervention	46.5 litres
Net saving per shower	3.8 litres per shower
Saving in Energy input to heat water (Assumption = water is heated from 16°C to 40°C, Heat added = specific heat x mass x (tfinal - tinitial))	0.1060656 kWh per shower
Annual Energy Saving (Assumption 1100 showers p/a between four primary users)	116. 67216 kWh
Annual Water Saving	4180 litres
Annual cost saving (Gas@7pence/kWh)	£8.16

As can be seen above, even with the very minor average reduction (-23 seconds or -3.3%) in the consumption of H37 the annual financial saving is £8.16 at current prices. Given that a production ready intervention device would be expected last for 5 years, it would have to cost less than £40.00 to make purely economic sense. However this technology is not very expensive and could easily be incorporated into a shower housing for little cost. It seems likely, given the range of savings made across the group that similar technology could prove to be cost positive.

Staying with the low energy reduction of H37, if we apply the same 5 year use case a total of around 575kWh is saved. While it is impossible to accurately estimate the embodied energy in whatever form a final design of this concept might take, it is likely to be significantly less than this.

It is important to state that these figures are a projection of the future consumption of the two chosen households. This projection is purely numerical and does not allow for shift in motivation, consumption or a further reduction in engagement with the intervention over that time. While it is correct to be conservative in these estimations, the savings resulting from the device in the main bathroom of H43 are altogether more considerable than those of H37. Obviously this is because of a baseline average duration which was considerably higher in H43, as well as the behavioural response of the participants. However, it is interesting to note that the post-intervention average showering time is very close in both houses.

7.5 Conclusions

This chapter outlined the nature of a medium length trial of a DfSB intervention device aimed at reducing longer showering times. Overall the trial is considered successful both in terms of generating meaningful change in the participants' behaviour but also in terms of validating the theoretical framework driving this research.

Of the five households in which the intervention device functioned successfully, four exhibited a positive change in environmental behaviour, i.e. shortening of the average shower duration. In the one house which did not exhibit a positive environmental change (H40), qualitative enquiry uncovered a number of reasons which might explain this.

The intervention was developed in accordance with the conceptual model and the Behavioural Intervention Selection Axis, developed from the previous research activities. One of the primary aims of the trial was to act as a case study illustrating the validity of these theoretical constructs and their efficacy in guiding the design of DfSB interventions. It appears that the conceptual model provides a useful lens for looking at the complexity of energy consuming behaviours. In comparison with other popular but more complex models of behaviour in use in the field of DfSB, such as Triandis' (1977) Theory of Inter-Personal Behaviour, the conceptual model allows the designer to investigate behaviour in more accessible terms by looking at active goal frames and the level of situationality.

At the core of the conceptual model is behaviour driven by active goal frames (after Lindenberg & Steg, 2007). This behaviour can, through repetition and expectation filters, develop a level of context driven automaticity which the conceptual model terms situational behaviour.

The qualitative findings of the group interviews conducted with the participant families support this contention in relation to showering behaviour. Many participants spoke of a difficulty in keeping track of time and a propensity to drift off. This was in line with the literature which guided the design of the intervention.

The design of the intervention had sought to interrupt this situational behaviour through audio and visual spurs and to refocus the user's reflective attention on finishing the shower in an efficient manner. The intervention was successful in achieving this, with all participants agreeing that the audio and visual feedback would cause them to speed up their showering behaviours to some degree. This finding helps validate the

Behavioural Intervention Selection Axis as a tool for guiding DfSB intervention development.

Furthermore, the ability of the intervention to interrupt deeply situational automatic behaviour and bring the user back to a reflective state (if only temporarily) created the opportunity for the intervention to initiate new active goal frames in the user. These new active goal frames were not just based on the user's pre-existing motivations in terms of saving money or not wasting water, but were mediated by the agency of the intervention into an entirely new arena. In this sense, it is clear that the intervention developed a prominent role as a non-human social actor in the behavioural space, engendering new motivations, e.g. competition, and a host of emotional responses, e.g. guilt, affection etc.

The agency of the device in the motivational sphere is an extremely interesting finding as it allows the designer to use persuasive technology to create behaviour changing motivations which exist only in relation to the designed intervention. To put this in human terms, it is akin to a student working hard to achieve good marks in an exam to spite the teacher who said they wouldn't do well. In broader terms, it opens the door to design interventions inhabiting an emotional role in the lives of their users, which create their own motivational dynamic, separate to the motivations previously underlying the user's target behaviour.

While the design intervention can be considered successful within the context of the theoretical underpinnings of this research project, it must also prove successful in the context of the larger research field; Design for Sustainable Behaviour. In order to assess its success in this realm the intervention trial was evaluated using Wilson's (2013) comprehensive DfSB criteria. This criteria seeks to establish if the design intervention was successful in three main aims; did the design function, did it cause a change in the user's behaviour and was this change sustainable.

Obviously, given the range of participants and results, this cannot be a uniform yes or no answer. However, as shown in section 7.4.2 the intervention was broadly successful across all three criteria. This is a significant development in the field as it shows not just a clear quantitative reduction in energy consuming behaviour, but the qualitative analysis also provides some insight into why this was the case.

Wilson's (2013) evaluation criteria are generally very useful in determining the success of an intervention, and the three main categories are considered correct and pertinent to the field. However, the sub-questions comprising the detail of the evaluation are perhaps too reliant on the particular behavioural theories which guided the author's research framework. That is not to say that these behavioural theories are incorrect, but rather, given the large number of conflicting behavioural theories underpinning the research of practitioners in the field of DfSB, a more generalised approach might be more successful.

It is clear that by having both quantitative and qualitative data this research was at an advantage to other work undertaken in this field. It seems impossible to accurately ascertain whether or not a DfSB intervention has been successful without collecting quantitative consumption data in some form. Equally, quantitative data without qualitative enquiry lacks meaning, particularly in terms of the researcher understanding why their approach was successful or not. That this trial had both forms of data collection underpinning it was not accidental, but rather a reflection of this understanding.

One of the strongest findings to emerge was the clear need for any DfSB intervention to engage different levels of user in the long term. While the intervention proved to be continually challenging for users with a longer showering routine, leading to very strong motivational and emotional responses, for users who were already efficient its engagement was generally limited to being a digital companion who provided positive affirmation. Many of these more efficient users were keen to further reduce their showering times, and their routines could perhaps have allowed further reduction. While this had been considered in the design of the intervention, the inability of the device to differentiate between users had led to a uniform approach for all. In future, DfSB interventions should seek, where possible, to facilitate these personalised approaches.

8. Validation of the BISA as a Tool to Guide Design

8.1 Introduction

This chapter provides an overview of the evaluation of the BISA as a tool to guide design. It details the nature of the testing and iteration the BISA went through, and evaluates its usefulness against an established set of criteria.

8.2 Aims

This chapter aims to answer the following research objective:

6. To concurrently test the Design for Sustainable Behaviour intervention selection axis suitability for use by designers.

As both the conceptual model and the Behavioural Intervention Selection Axis model aim to further the successful application of DfSB theory in design practice, the study was conducted as an applied design workshop. Common outputs of research in this area are design cards or a toolkit (Lockton et al. 2010; Lofthouse 2011; Daae 2014) and workshop materials (Escobar-tello 2010). But this study was not necessarily concerned with generating a format or toolkit for a DfSB workshop. It was focused on ascertaining the relevance and usability of the BISA to design, as practiced at University level.

8.3 Methodology

The study consisted of an immersive session of lectures and a workshop on DfSB theory with an explicit focus on the understanding and application of the conceptual model and Behavioural Intervention Selection Axis model.

The study was undertaken in two parts. The first session was conducted in February 2013 and was the first time that the conceptual model and BISA were introduced to designers as tools to guide their own practice. As such, it was anticipated that there would be some teething problems and the aim of the first session was to highlight any issues and resolve them. In this sense the first session can be viewed as a pilot trial. Therefore no attempt was made to apply any metrics to the success or failings of the tools. Instead, particular attention was paid to analysing the nature of the participants' engagement with the tools. Based on this, it was hoped, weaknesses in the tools could be discovered and corrected prior to subsequent evaluation. This process is directly analogous with the cycle of iterative development inherent in user centred design processes, which have guided this research at large.

The second workshop session took place in November 2013, using slightly revised materials in a similar format. This workshop was used to evaluate the suitability of the conceptual model and BISA as tools to guide design.

In both the first and second sessions, the students were given a set of three lectures on Sustainability, DfSB, User Research methods and Ethics to provide them with an overview of the area and an insight into the impact of energy consuming behaviours (ECBs) and their relationship to design and context. The lectures on DfSB included much of the theory covered in Section 2.5 but also included the conceptual model developed by the author in Section 5.3 as way of framing the interconnectedness of ECBs and the individual and their context.

Figure 8-1. Workshop One ECB brainstorming session.

The class was then divided into groups to interrogate their own behaviours and experiences and to identify a range of wasteful or inefficient domestic ECBs (Figure 8-1and 8-2). The session was facilitated by the author with a strong emphases that there were no “wrong” answers and that they should consider all their domestic behaviours and then seek out any energy related inefficiencies or waste within them. Asking them to look at their own lives (as opposed to others’) through the lens of DfSB had a dual purpose. It allowed for the generation of a large list of real ECBs in a short period of time without the need for a lengthy user study. It also allowed them to gain first hand insight in to how their behaviours were shaped by the interfacing of their own knowledge, attitudes, and beliefs with the physical and societal context they acted with-in. By doing this in groups, they were spurred on to greater insight by the admissions and suggestions of others. All the perceived wasteful or inefficient ECB were recorded on Post-It notes.

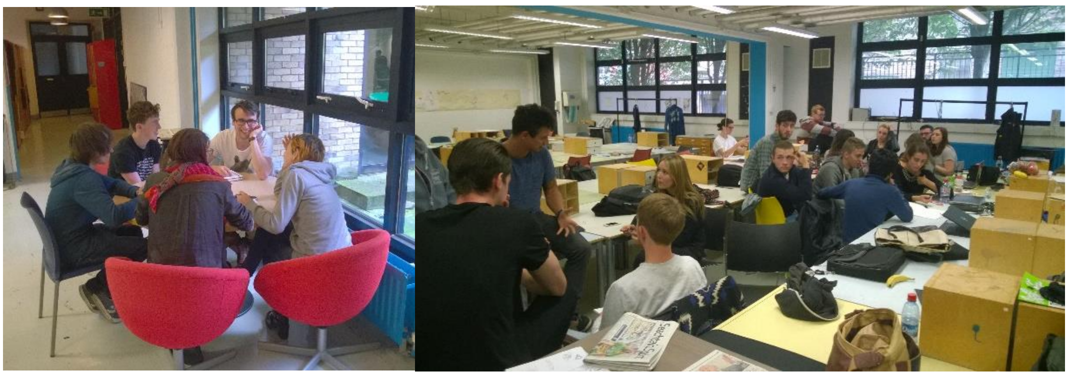


Figure 8-2. Workshop Two Brainstorming Session.

Following this brain storming session, the students were given a short presentation on the Behavioural Intervention Selection Axis detailed in Section 5.3 The nature of Reflective and Situational Behaviour were explained and concept of the sliding scale was expanded upon, additionally the relationship of the intervention selection to behaviour was detailed. The students were told that the purpose of the exercise was to see if they could position a selection of their identified behaviours on the axis and to see if they felt that the level of intervention was appropriate. It was explained that the model was a tool under development and that they may find that it didn't work in every case but that that was not their fault, but the model's originators.

To gain insight into the reasoning behind any choice and to uncover any issues with applying the model the students were asked to verbalise the thinking behind their choices including any difficulties with the author asking questions as deemed appropriate. This method is commonly used in HCI usability evaluations and is termed "cooperative evaluation" (Monk et al, 1993). A large scale printed Behavioural Intervention Axis was stuck to the wall and students came forward in turn to position their behaviours and explain their thinking (Figure 8-3). The session was videoed to provide a record of the students thinking while allowing the author to focus on facilitating and asking relevant questions.

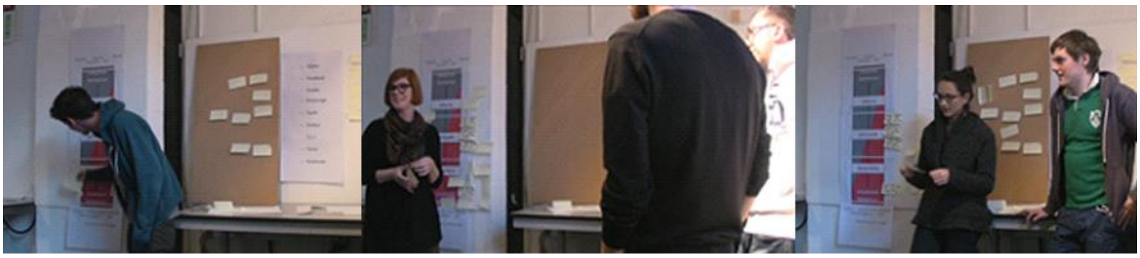


Figure 8-3. Cooperative Evaluation session.

Having placed the behaviours on the BISA, the groups were asked to choose one behaviour to conceptualise a design intervention for using the strategies suggested by the

BISA. Due to the limited time frame left for this activity, these concepts were descriptive in nature rather than fully rendered design ideas.

8.4 Findings

Due to each session having a different purpose, as discussed in section 8.3, the findings from each will be dealt with separately and in sequence.

8.4.1 Findings from Session One

The first behaviour identification exercise proved very interesting and valuable in the refinement of the BISA. The students found the definitions of the terms reflective and situational behaviour to be understandable yet broad enough to allow for individual interpretation. This meant that the students' design skills could be fluently expressed in the so called "fuzzy front end" without having to channel their thinking through a linear dogmatic process. Such flexibility in a methodological design tool does not necessarily imply inaccuracy or weakness but rather it is necessary reflection of what Stappers et al (2007) call "a set of delicate balancing acts" (see Table 8-1).

Table 8-1. Stapper et al's (2007) set of balancing acts for design tools.

a. between informal and formal methods
b. between information (validity) and inspiration (actionability)
c. between finding questions and finding answers
d. between ambiguity and precision
e. between empathy and understanding (stepping in and stepping back)
f. between quotation (raw data) and interpretation

The cooperative evaluation approach gave excellent insight into the students' understanding of the BISA and allowed a number of issues to be uncovered. In the majority of cases, the identified ECBs fitted well on to the axis in a logical manner with the students understanding and appropriating the relevant terminology.

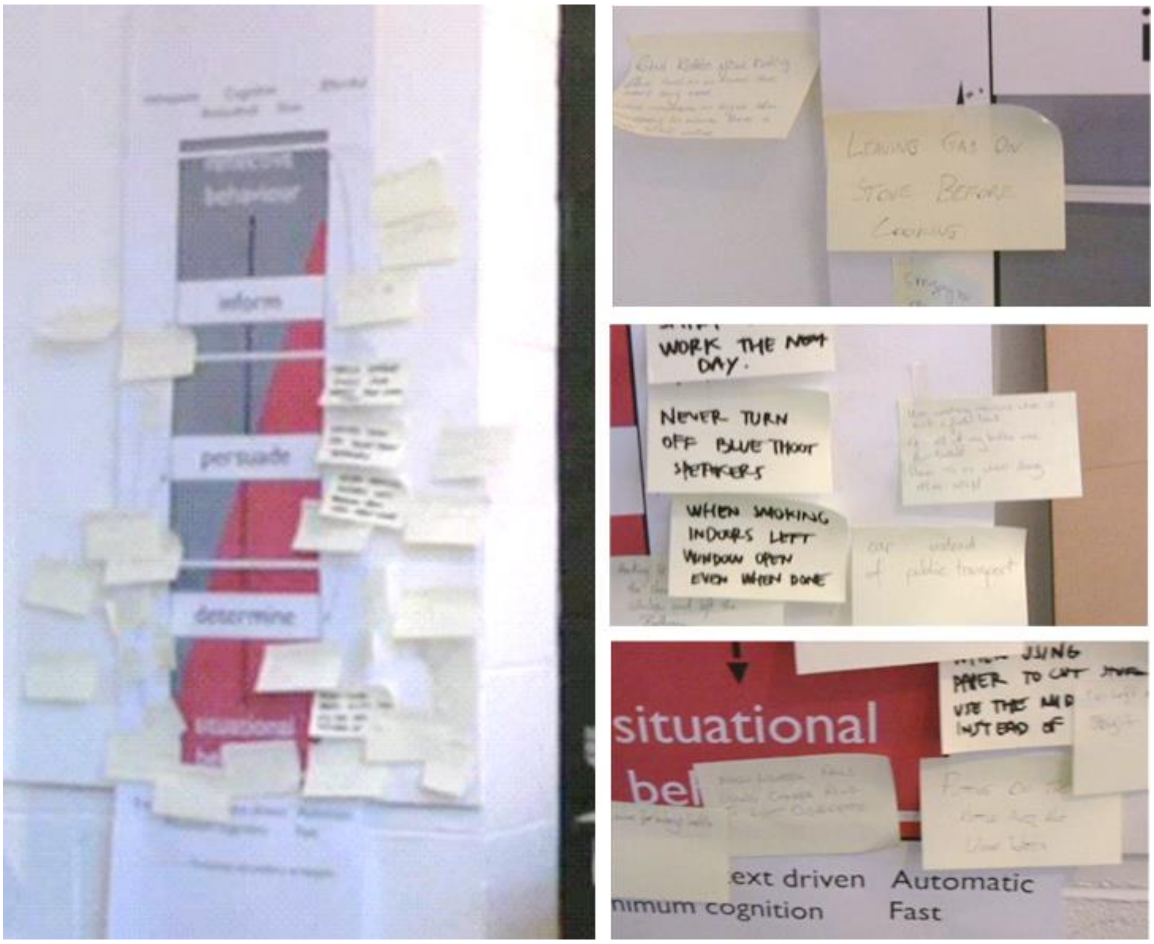


Figure 8-4. BISA Workshop One.

Interestingly, the vast majority of the resource consuming behaviours identified were judged by the students to fall in the lower two thirds of the axis; that is behaviours exhibiting a significant degree of situationality (see Figure 8-4). By extension the BISA would dictate that these behaviours would require an intervention with a stronger degree of agency than information alone (see Table 8-2). This is a finding very much in line with the User Study and literature review which point to a lack of impact from informational interventions on domestic ECBs.

Table 8-2. Selection of Identified ECBs in descending degrees of Situationality.

Leaving the immersion on too long to make sure there's enough hot water for a shower. *"I know it's probably too long but I want to make sure that the water doesn't go cold when I'm half way through the shower."*
Leaving Bluetooth speaker on all the time. *"I have Bluetooth speakers and because you can just play music from your phone you never actually go over and turn them off."*
Smoking with the window open when the heat is on. *"I suppose I do it because I don't want to go out into the cold, but then I forget to close it and I end up freezing inside a cold room instead."*
Lighting gas ring on cooker but not actually being ready to cook on it for 5 mins. *"You light it but then you remember something else to chop or you get distracted."*
Opening the fridge door just to stare inside and think about maybe having something. *"I'm thinking about food or what I'll make for dinner, but I never think about all the wasted energy."*
Leaving the curtains open with heat on until going to bed. *"I never thought about this until now, but my friend told that , like, 70% of the heat goes out through the windows and that curtains can keep a lot of that in but we never actually started to close them" "I like to leave them open so I can wake up more naturally."*
Flushing the toilet just to dispose of a single tissue. *"I always do it and afterwards I'm like, "I shouldn't have done that!"*
Leaving shower running but stepping out of water while leathering. *"You don't really think about it, you're just focusing on cleaning yourself."*
Using the Tumble dryer for every wash. *"I don't even question it, it just goes straight in."*

The groups chose one "problem behaviour" to address. They used it as a focus point with which to develop a design concept, while applying the relevant intervention strategy. The broad descriptors used on the axis (inform, persuade, determine) provided suitable guidelines for the students without being overly prescriptive. The concepts were not brought to a very high level of resolution, but were produced in the form of heavily annotated working sketches. None of the groups expressed major difficulty in applying these intervention strategies. On one hand, this is unsurprising as these strategies have been successfully used in various forms by a number of designers and researchers since first proposed in a similar structure by Lilley (2007). On the other hand, it can be seen to imply that the students felt that the type of intervention strategy suggested by the BISA was appropriate in its level of agency to match the nature of the behaviour they were trying to change.

8.4.2 Problem Behaviours and Amendments to the BISA

As was hoped prior to this session, some previously unresolved aspects of the BISA were brought to light by some of the identified ECBs which did not fit so easily on the axis

(Table 8-3). These were behaviours which could not logically be solved through the intervention strategies outlined in the DfSB axis.

Table 8-3. Problematic ECBs.

Having to use washing machine and tumble dryer regularly to clean a single shirt for work. *"I know it's bad but I need to do it….I suppose I could buy another shirt."*
Router left on 24 hours a day. *"I know it shouldn't be on but I really like to be able to wake and check my emails first thing."*
Buying inefficient bulbs because the low energy ones are too expensive. *"I spend a fortune on electricity, but those bulbs cost way more than the old type, especially the unusual shapes can cost €20."*
Boiling the kettle 20-30 times a day to make sure there is hot for baby's bottle in case they start to wake up. *"I know it ridiculous but every time she stirs in the night, I jump up and run down and boil the kettle so if she wakes I can give her a bottle. Most of the time she'll go continue to sleep and water is never used, but if she does wake and there is no bottle ready I could be up for the night!"*
Leaving the mains switch for the cooker power on. "You see the switch is on the wall behind the cooker and you can't get to because the cooker is in the way, but I know it using energy."
Opening oven door to see how food is cooking, because glass in door is dirty *"I know it's bad, but otherwise you can't see what's happening."*

These ECBs were mainly on the reflective end of the scale but would not be solved by any of the intervention methods proposed by the BISA, i.e. inform, feedback, spur, etc. Further analysis of the video recording revealed these ECBs to be significantly constrained by the needs of the user or by the nature of the context. While these factors could easily addressed through a user centred design approach, they initially seemed to indicate a weakness in the theoretical validity of the BISA.

It became apparent that the BISA was effective as a tool for guiding a change in behaviour, but only when that behaviour was made possible. This is an obvious observation and one in line with the literature concerning User Centred Design and DfSB (Wever et al. 2008; Lidman et al. 2011) guiding this research, but it was hitherto never explicitly stated in relation to the Behaviour Intervention Selection Axis.

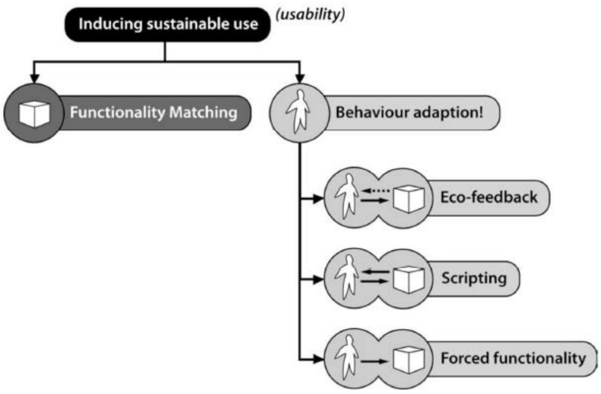


Figure 8-5. Wever et al's (2008) dual branched typology of behaviour inducing design strategies.

Following on from this the BISA was modified to incorporate Wever et al's (2008) concept of functionality matching (Figure 8-5). Functionality matching recognises that there is an opportunity to reduce environmental impact by better matching the product's functionalities with those desired by the user.

"Redundant functionalities have an unnecessary impact, while missing functionalities can trigger unwanted behaviour, with subsequent unsustainable effects." (Wever et al. 2008)

Functionality matching was added in the same dual branched typology format as Wever et al's (ibid) as this better differentiates it as a concern separate to the axis. Figure 8-6 below, shows the revised Behavioural Intervention Selection Axis.

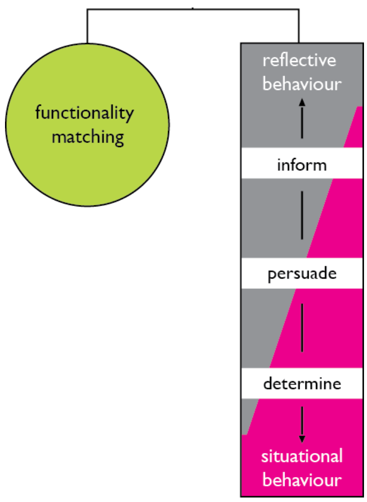


Figure 8-6. Revised Behavioural Intervention Selection Axis with functionality matching included.

8.4.2 Findings from Session Two

As stated, the format for the second workshop session was broadly similar to the first. The major change in content was the explicit addition of functionality matching to the BISA, as deemed to be required from the findings of session one. In addition, the number of ECBs selected to place on the BISA was reduced to 3 per team to reduce the amount of time taken by the workshop. The students were also asked to complete an evaluation of the BISA following the workshop.

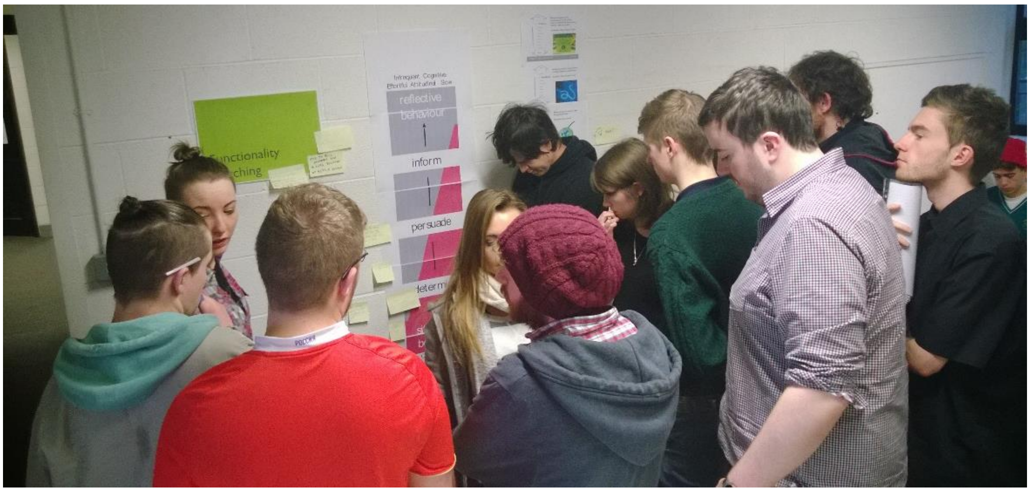


Figure 8-7. Workshop Two.

The addition of functionality matching proved highly successful in terms of providing the necessary category for observed “problem behaviours”. In the first session there were a number of “problem behaviours” which defied categorisation on the BISA as they were not behavioural issues per say, but were related to the inadequacy of technology in meeting users’ needs. In the second session, any such behaviours were easily identified by the students as being a question of functionality matching, rather than behavioural intervention (see Figure 8-8).

Figure 8-8. BISA used in Workshop Two showing addition of functionality matching.

Observation and reflection by the researcher was used to gauge the general efficacy and suitability of the materials as design tools, and this proved successful in both workshop in highlighting key areas for iteration. However, at the second workshop it was also desired to gather qualitative feedback from the students themselves, as final users of the design tools. The students were asked to complete an evaluation of the BISA after the workshop had completed. This evaluation took the form of a questionaire and feedback sheet with 5 questions, each with a 5 point Likert scale and free comment section.

It was hoped that the feedback from the evaluation could determine whether the BISA exhibited the necessary characteristics for design tools, as outlined by Lindahl (2005), see Table 8-4 below. Lindahl's fourth characteristic could not be fully validated in the context of a 2 hour workshop with students who have not experienced working with alternate methods or even in this field of design before. What could be comprehensively asscertained however, was the the usability and ease of implimentation of the BISA. This is considered the most critical characteristic of a design tool. In additon it was hoped that the broad nature of the questions and the participants comments would provide an insight into how well the BISA addressed the remaining characteristics.

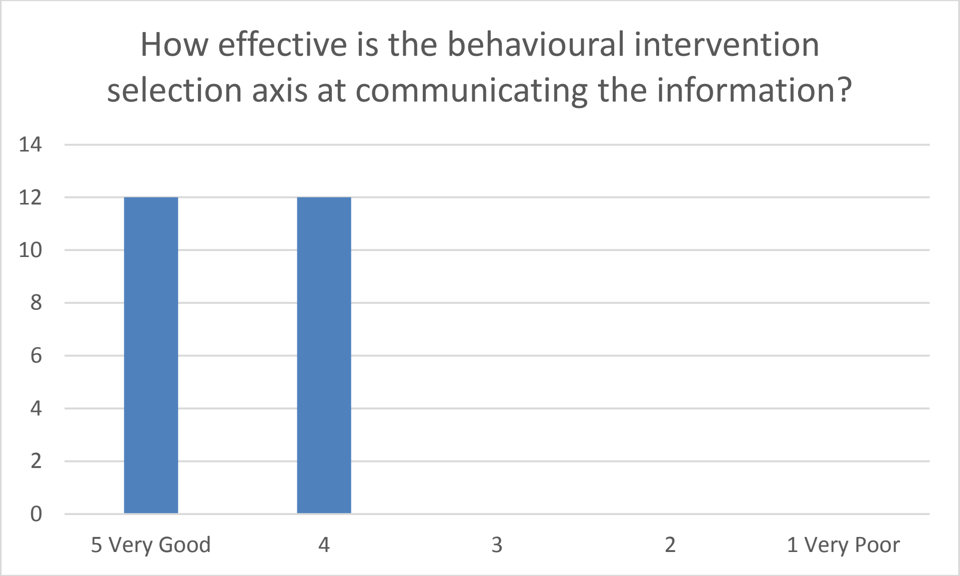
Table 8-4. Essential characteristics of Design for Environment methods and tools (Lindahl 2005).

1. Be easy to adopt and implement. Whether a method or tool fulfils the three following requirements is of lesser importance if leads to problems with adoption and implementation and is seen as having a low degree of usability, and therefore is not utilized by the designers in their daily work. This requirement is the key for a method or tool to become actively used.
2. **Facilitate designers to fulfil specified requirements on the presumptive product.**
3. **Reduce the risk that important elements in the product development phase are forgotten.**
4. **The use of the method or tool must reduce the total calendar time (from start to end) to solve the task.**

How effective is the behavioural intervention selection axis at communicating the information?

The first question asked the students how effective the BISA was at communicating the information. The aim of this was to garner whether the students were able to easily understand the model's abstraction of complex behavioural literature into a simplified sliding scale. This is important as designers are unlikely to find it easy to use (i.e. Lindahl's first characteristic) if it does not communicate the information well. The students responded positively (see Table 8-5 below) with all Likert responses being either good or very good.

Table 8-5. Response to question 1 of BISA evaluation.



The comments show that the sliding scale is an immediately recognisable format, and simple to understand.

> *"Very simply laid out colour and labels."* ***WS2_6***
>
> *"Very understandable."* ***WS2_17***
>
> *"Pretty good, but I am a designer looking at this from the point of view that I've looked a roughly similar types of thing before, might not be so clear for someone else."* ***WS2_23***

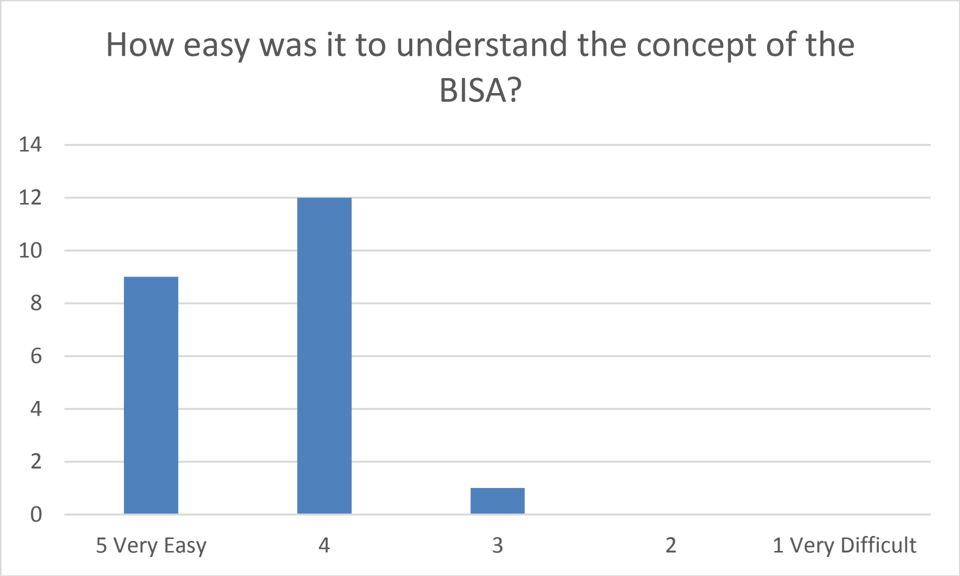
The responses begin to indicate that the BISA fits the first characteristic of Lindahl's ; that the model be easy to adopt and implement

> *"It's easy to relate to my own behaviour."* ***WS2_3***
>
> *"Quite clear, little explanation needed."* ***WS2_2***
>
> *"It shows there are different reasons for things but it shows the average of behaviour."* ***WS2_13***

How easy was it to understand the concept of the BISA?

The second question asked how easy it was to understand the concept of the BISA. The aim of this was to determine whether the complex intangible concepts represented by the model could be understood without taxing the designer too much. Given that this was the first time that the students were introduced to the area of DfSB, the response again was very positive with all but one student recording that the concept was either easy or very easy to understand, see Table 8-6 below.

Table 8-6. Response to question 2 of BISA evaluation.



These comments indicate that the BISA appears to have had a low threshold for comprehension and subsequent adoption for the student designers, in part answering Lindahl's (ibid) first characteristics.

"I got a good grasp of the model." ***WS2_4***

"It's easy to read and simple." ***WS2_10***

"Rather easy, near immediate. The 'Inform, Persuade, Determine' takes a bit more to understand." ***WS2_17***

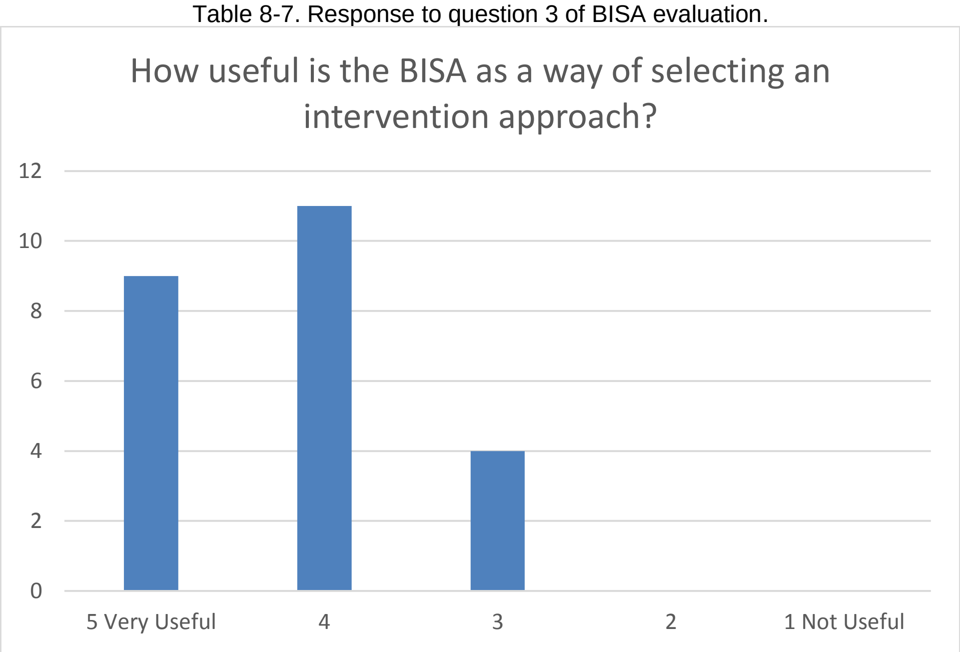
However it was clear that there was an initially steep learning curve for many students as they engaged with the concepts of product agency, behavioral theory, and intervention approaches for the first time.

“Easy at the end, hard at the beginning.” ***WS2_7***
“Takes some time to grasp the concept but once you have its grand.” ***WS2_21***
“On first glance the range on the spectrum needs further explanation.” ***WS2_3***

How useful is the BISA as a way of selecting an intervention approach?

This question sought to provide insight on 2 of Lindahl’s characteristics; be easy to adopt and implement, and facilitate designers to fulfil specified requirements on the presumptive product

Table 8-7. Response to question 3 of BISA evaluation.



Again the majority of the students found the BISA to be useful (see Table 8-7), but a small number struggled with open nature of the behavioural scale. Overall there is promise the BISA is relatively easy to adopt and implement, with some students stating how it allowed them to see both their own, and others’, behaviours as being subject to change given the relevant intervention strategy.

“It’s easy to consider approaches that would cause you to adjust your own behaviour.” ***WS2_3***
“It helps you think differently, in a way you are not accustomed to.” ***WS2_4***

> *"Distinguishes where the problem lies as unconscious or conscious and where to approach it from." WS2_17*

The main difficulty expressed by those who struggled was knowing where to place a given behaviour on the scale. This indicates that further attention to should be given to providing examples which demonstrate the positioning of different behaviours. However this must be balanced against leaving enough room *"for finding questions and finding answers"* (Stappers et al. 2007), to ensure that future users interrogate any target behaviour sufficiently.

> *"Sometimes it's difficult to know where something belongs."* ***WS2_10***
> *"It confuses me because you could approach it in so many ways."* ***WS2_13***
> *"Some things fitted along the whole scale rather than one compartment."* ***WS2_12***

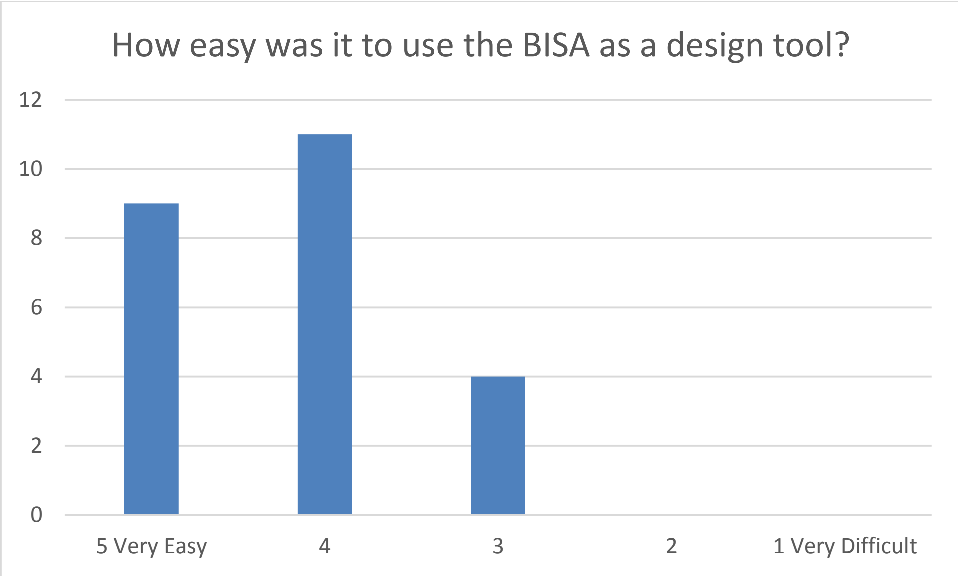
The responses indicated that the BISA did facilitate designers to fulfil specified requirements on the presumptive product. In this case the specified requirements are the appropriate intervention strategy, the final nature of which is dependent on the specific behaviour, context, and related products being targeted.

> *"Very useful, allows you to categorise what is essential."* ***WS2_23***
> *"It's a good way to try and find something very now."* ***WS2_21***

How easy was it to use the BISA as a design tool?

Perhaps the clearest assessment of the BISA meeting Lindalhs (ibid) criteria can seen with this direct question. The questionaire responses (Table 8-8) showed that 20 of the students found the BISA Easy or Very Easy to use as a design tool, while 4 found it niether easy nor difficult to use.

Table 8-8. Response to question 4 of BISA evaluation.



The written responses give a further strong indication that the BISA was not just easy to adopt and implement but that it actively helped with the task of designing rather than just providing boundaries for it.

> *"Straight forward, encouraged us to keep looking for the solution after finding a first one."* ***WS2_23***
> *"It's opened my mind a bit more, iteration and coming up with a range of ideas will be a lot easier."* ***WS2_20***
> *"I can see how it would be helpful for concept generation, although I haven't fully designed something using this model."* ***WS2_21***
> *"It's useful and gives direction."* ***WS2_10***
> *"Easy to implement these ideas and techniques into the project."* ***WS2_19***

Interestingly further response indicated the BISA fits characteristics 3 of Lindahl; that it reduce the risk that important elements in the product development phase are forgotten. Many students commented that it brought important aspects to their attention which might otherwise have been overlooked.

"It was great for shining a light on aspects of use that would have been ignored or just not considered." ***WS2_14***

"Found it useful as I notice things I never noticed before." ***WS2_7***

"It helps you think differently, in a way you are not accustomed to." ***WS2_4***

"Not easy in that everything has a set place, but this is better as it makes you consider the action and the thought process." ***WS2_17***

Those who found the tool less useful said it was due to the perceived complexity of the BISA as a design tool. This is not unexpected, particularly when one considers the limited exposure the students had to the subject matter.

"It can be very brain consuming." ***WS2_4***

"Took a few minutes to get your head around." ***WS2_18***

How likely would you be to use the BISA as a design tool for any future Design for Sustainable Behaviour projects?

Table 8-9. Response to question 4 of BISA evaluation.

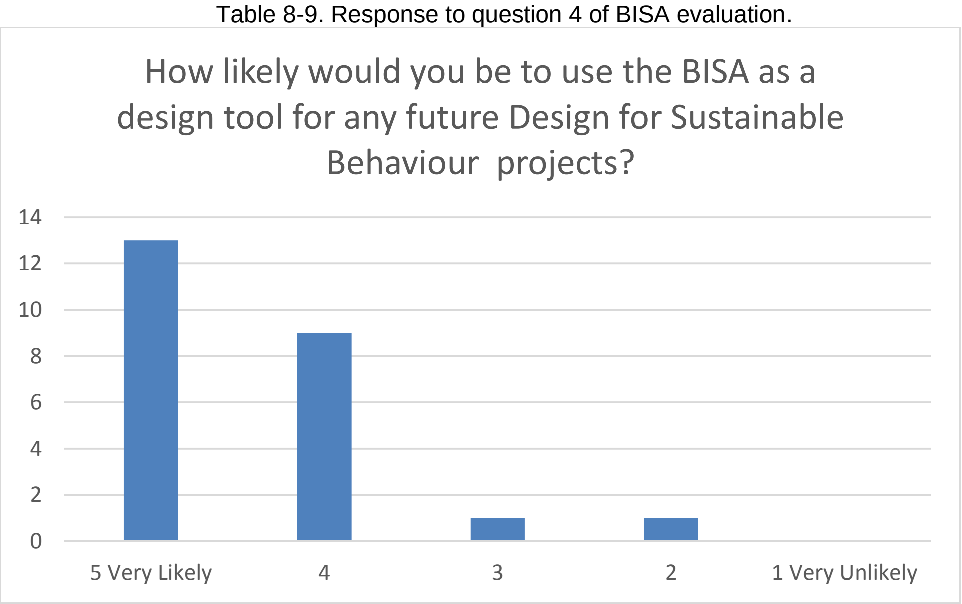


Table 8-9 above shows that the vast majority of the students stated that they would use the BISA again as a design tool in future DfSB projects. This provides fairly conclusive evidence that the tool is easy to adopt and implement for the majority of students.

> *"Very likely providing it's of relevance to the project."* **WS2_4**
> *"Found it very interesting, even using the concept in other projects just with different values."* **WS2_20**
> *"Very likely, useful tool to have."* **WS2_7**
> *"I think I would be likely to use it in the future."* **WS2_21**
> *"It really helps us realize that habits could be changed to easy sustainable habits."* **WS2_13**
> *"It's opened my mind a bit more, iteration and coming up with a range of ideas will be a lot easier."* **WS2_20**
> *"It is an interesting way to put across ideas and idea generation is more flowing."* **WS2_5**
> *"It aids the process."* **WS2_10**
> *"Very useful check list."* **WS2_18**
> *"Great for clarification."* **WS2_17**

8.5 Conclusions

In conclusion the workshop sessions have achieved their aim in ascertaining the relevance and usability of the BISA to design, as practiced at University level. The first workshop provided a clear indication that the BISA appears to follow an appropriate path between the necessary set of balances identified by Stappers et al (2007). That is it provides a solid scaffold on which design students can hang their own interpretations and explore further while remaining in the correct theoretical space. This balance between informality and formality is considered a key requisite for the successful uptake and implementation of any design tool. Furthermore, the graphic and conceptual simplicity of the BISA compares favourably with more complex intervention selection models proposed by a number of researchers exploring the relationship between psychology and DfSB (e.g. Tang & Bhamra 2008; Zachrisson & Boks 2012). As shown by the results of the feedback questionnaire, this allowed nearly all the students to clearly grasp the key variables of the model in a quick, generative workshop setting.

The first workshop identified an oversight in the theoretical makeup of the BISA, the need to allow for functionality matching (as per Wever et al. 2008). This was a key finding which, though obvious in hindsight, was only uncovered through the real world application of the BISA by other designers. The inclusion of functionality matching allowed the students in the second workshop to successfully place all of their observed ECBs satisfactorily on the BISA. This demonstrates the utility of the model in guiding design intervention for designers other than the author.

The efficacy of the BISA as a tool for design was determined against the characteristics laid out by Lindahl (2005). The primary characteristic for determining the success of any tool was that it be easy to adopt and implement by designers. Both the observed actions of both groups of students and the feedback questionnaires completed by the second group of students strongly indicate that the BISA met this characteristic for the vast majority. This is considered absolutely necessary for any design tool, as regardless of how well it helps the designers achieve their desired output, no tool will be used if it is seen to have a low degree of usability.

Lindahl's second characteristic is that a design tool facilitate designers to fulfil specified requirements on the presumptive product. By balancing different intervention strategies against the nature of the behaviour which they are targeting, the BISA helped the students explore concept ideas grounded in the specific requirements of the behaviour. Several students commented how the model helped them see the real nature of the ECB they were targeting or helped them categorise what was essential to account for.

Reducing the risk that important elements are forgotten from the product development phase is the third characteristic of successful design tools. This too can be considered to have been achieved by the BISA, with quite a number of the students commenting how the model forced them to consider important aspects which they would otherwise not have thought of.

As previously stated, the fourth characteristic of effective design tools, that the use of the method or tool must reduce the total calendar time to solve the task, could not be verified in the scope of this research activity. By its nature this requires that the designers have attempted to solve a similar design problem before and therefore have a baseline duration to compare with. This was not the case with this group of designers and so the BISA cannot be said to be validated in this respect.

This omission is one of a number of limitations of this study in addressing its stated aim. Other significant limitations are of course the sample size involved, the duration of the two studies as workshop sessions, and the experience level of the participants. These limitations aside, there is still considerable evidence that the BISA can be considered a useful and effective tool to guide intervention design.

It is impossible, however, to position the efficacy of the BISA against other models documented in the research. To do so would require a larger controlled test, involving experienced designers utilising a range of models to ascertain which of the models could prove most useful.

9. Discussion

9.1 Introduction

This research sits firmly in the field of DfSB and has sought to identify and investigate weaknesses and gaps in the field and propose innovative theoretical constructs to address them. As a substantial review of existing DfSB literature was conducted in chapter 2, the majority of this chapter is given over to discussing the implications of the new theoretical constructs subsequently put forward. It will attempt to show the validity of these constructs using the findings of the research activities undertaken and position them within the DfSB cannon.

Previous chapters have discussed their respective findings in relation to the stated aims and objectives of the relevant research activities contained within each. This chapter, however, will discuss the wider implications of the research findings at large. It will seek to provide a holistic overview of the theory development contained within this thesis, drawing on evidence from within the research activities and linking them to the wider research field. It seeks to highlight emergent areas uncovered through the research activities and position them against relevant literature. Some of these emergent findings are outside the remit of the original research aims and objectives. As such the relevant literature has not been covered in the literature review, but will be discussed here.

9.2 Development of DfSB Theory

Goal framing theory is an elegantly simple and useable behavioural model to describe energy consuming behaviours. It provides insight into the intentionality of user behaviour in clear, easily understood human terms. As shown by the findings of the User Study, this clarity and simplicity allows for easy interpretation and alignment of the everyday speech used by people when speaking about their behaviours and routines. As a theory, goal framing may or may not be as empirically valid or comprehensive as other theories, such as Triandis's theory of interpersonal behaviour (1977) or Klöckner & Blöbaum's CADM (2010), but it is however a far more useable construct in terms of design research.

As visualised in the conceptual framework, it allows the designer to give form and weight to the motivations driving a given behaviour. As used in this research, it allows for the aggregation of different people's motivational goal frames into a single construct to guide design. This aggregation may not be a theoretically pure interpretation of goal framing theory, but it has provided a successful means of keeping key motivational factors in the design space.

In creating the sliding scale of behaviour (see Figure 9-1), the author has streamlined the representation of the establishment of habits as proposed by a number of sources in the literature. Though clearly an evolution of the work of Tang (2010), the sliding scale addresses many of the issues of her application of Anderson's framework of acquisition of cognitive skill (1982). It removes the linear choice bracketing created by the set levels of intervention prescribed by her model. Also it more fully recognises the gradual development of habit and presents it as a progressive scale. This again allows for freer interpretation by the designer when considering the nature of behaviours reported through qualitative methods.

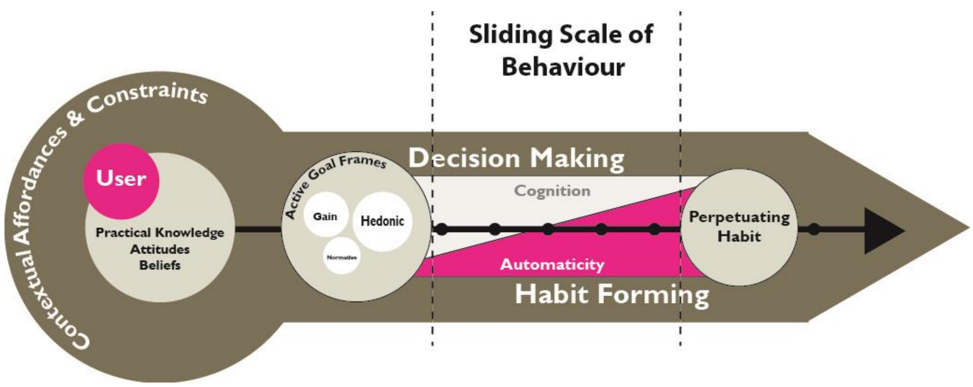


Figure 9-1. Identification of the Sliding Scale.

The concept of habit, though widely understood, was found to be too theoretically narrow to encompass the nature of many of the behaviours expressed by participants in the User Study. Habit is commonly defined as the delegation of control of behaviour to contextual cues. While this is certainly true of behaviours like opening the fridge door without knowing why or starting to drive to work on a Sunday morning, it does not adequately describe the full range of behaviours recorded. When participants spoke of daily routines involving running around the house quickly tidying, putting a wash on, emptying the dishwasher, and listening to the news all at the same time, they were exhibiting qualities better explained by Kahneman's model of bounded rationality (2002). That is to say, that there was an element of reflective cognitive processing in how they performed these routine tasks balanced by lots of fast, easy, automatic processing. They were constrained by time pressures but could still make balanced reflective decisions, e.g. sorting a wash, putting the right glasses in the right place etc., while reducing the cognitive load in the majority of the behaviour. Their behaviour was influenced by the situation they were in, that is their emotional state, external pressures such as lack of time, the number of other things they needed to think about at the same time, and other factors separate to just the physical context. It was the situation which determined how much reflective cognition would be given to performing routine tasks. It was for this reason that the concept of situationality was employed by the author.

In Section 5.3 the conceptual model was further extrapolated to create a sliding scale of behaviour between the highly cognitive Reflective behaviour and the semi-automatic Situational behaviour. This in turn was developed as an intervention selection tool which matched certain types of DfSB intervention strategies against the level of reflectivity shown by the user when engaging in a target behaviour. The tool also recognised that in some cases it is advantageous to disrupt a situational type behaviour, to refocus the user's cognitive attention and to bring a reflective behaviour to the fore (see Figure 9-2).

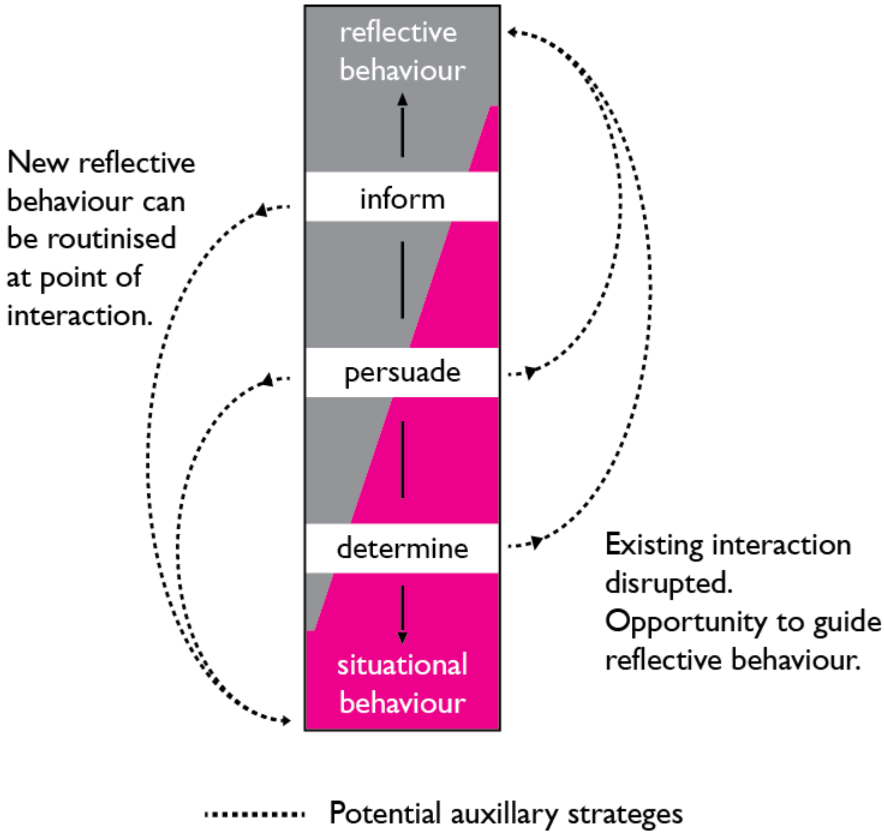


Figure 9-2. Behavioural Intervention Selection Tool.

9.3 Validation of the Conceptual Model and Behavioural Intervention Selection Axis through the Case Study of Showering

This conceptual model positions behaviour as the result of the interfacing of context and personal attitudes, belief and norms. These factors interface to create a range of behavioural possibilities. For example, while the context may constrain or facilitate given behaviours, the individual's personal attributes will guide what options are deemed possible and desirable by the individual.

To put this in terms relevant to the study, a combi-fed continuous heat boiler (context) would physically allow its user to have a shower of indefinite duration. However, the individual is likely to choose the length of their shower based on both external contextual constraints, e.g. time, or prominent attitudes, values or beliefs.

The interfacing of these attributes allows for a range of behaviours to happen. What determines the actual course of behaviour taken by an individual, is the active goal frame (Lindenberg, 2007) at the time of behaviour. The prominent goal frames determining energy consuming behaviours include hedonic, normative and gain, as discussed in Section 2.7.

To continue the example above, if the gain goal frame is dominant, the user may have a shorter shower because they believe it saves money on energy and water charges or that it allows them more time to do work or other productive activity. However, these goal frames are temporally changeable and the same user, after a tiring day, may choose to stay in the shower for a long hot soak. In this case the hedonic goal frame is to the fore as shown in Figure 9-3.

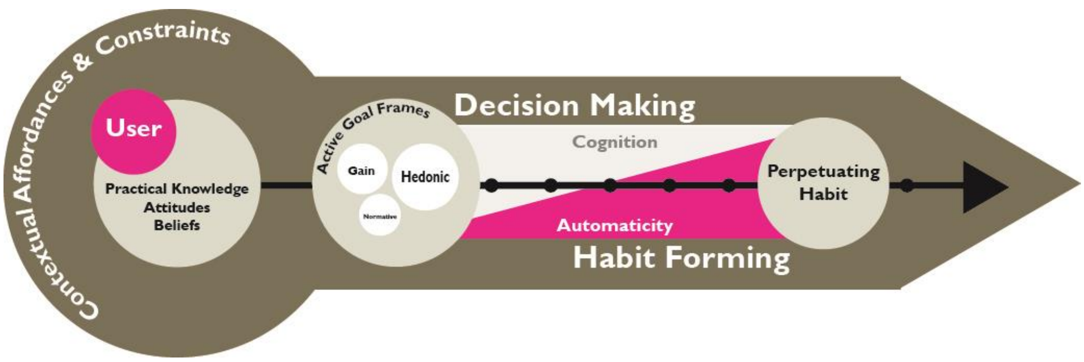


Figure 9-3. Conceptual model.

While these goal frames give form to decision making, much of domestic energy consuming behaviour appears to be undertaken semi-automatically with little or interspersed moments of goal frame based consideration. This automaticity comes not just from the frequency of performance, i.e. how often the behaviour is undertaken, but also from how little conscious cognitive effort is required to perform it. For example, behaviour like ironing clothes might require a high level of cognitive input in the course of its undertaking, but in comparison, the act of showering allows a large amount of cognitive disengagement from the primary energy consuming behaviour being undertaken. That is not to say that users aren't aware that they are taking a shower, or even the nature and length of that shower, but that there is a high possibility that their cognitive or reflective focus is elsewhere at different points during the shower.

This intervention trial was not primarily focussed on successfully reducing showering times, but sought to evaluate the efficacy and relevance of the conceptual model and Behavioural Intervention Selection Axis (BISA) generated in response to the Literature Review and User Study. As these had been used to guide the development of the intervention the results should allow, in part, for the validation of their effectiveness.

One of the main aims of the intervention development and trial was to provide an evaluation of the conceptual model derived from the literature review (see section 2.7). This section will give a recap of the conceptual model, show its utility in viewing the intervention trial, and determine the effectiveness of the Behavioural Intervention Selection Axis. In so doing, it will detail the large range of responses from the participants, showing their multi-faceted reactions to the arrival of the intervention, and detailing how their behavioural responses fit into the above mentioned model and axis.

9.3.1 Design Intent

It was believed from the literature and the analysis of the Practices studies (see Chapter 6.4) that there were two main drivers, often acting together, of long showering behaviours. Firstly, that it was driven by a hedonic goal frame which placed the immediate pleasure of showering in warm water foremost over any gain or normative goal frames that might have been present. Secondly, it was believed that for many people showering was a deeply situational behaviour which allowed their cognitive focus to drift off onto other matters and thoughts pertinent to them. Thus increasing the duration of the shower far beyond that needed for functional cleaning, without the user even realising it.

The design and development of the shower intervention device (Enuf) targeted both of these drivers. Using the means available to it, the device sought to disrupt these moments of low cognition (situational behaviour) to refocus the user's reflective mind on the consumption feedback. The format and metrics used by the device sought to replace the dominant hedonic goal frame with a gain or norms based goal frame. That is, to shift the user from being motivated by the pleasure of a long shower, to being concerned about the cost implication of the length of their showering, or that such long showering was not appropriate behaviour in terms of waste etc.

9.3.2 Personal and Contextual Attributes

This evaluation will examine the quantitative and qualitative information recorded by the device and subsequent feedback interviews with the participants. It will show how that in many cases the position undertaken in the design phase, the design intent (after Lockton 2010), of targeting these hedonic goal frame led behaviours and highly situational behaviours was proved successful. It will also show how such an approach was not universally successful, and how the intervention strategy could have been tailored better for users whose behaviour was not driven by these factors.

Following the format of the conceptual model, the participants were questioned about their attitudes, beliefs, and norms (Stern 1999) relating to showering. A range of attitudes towards showering emerged, where at one end of the scale a number of, mainly male, participants saw showering as a purely functional necessity. They recognised it as a way of maintaining hygiene, and for the most part showered daily, but tried to minimise the time spent in the shower as far as they could.

> *"I mean, genuinely my object is to get in and out in the shortest possible time anyway."* **H40MA**

> *"But yeah I'll just, well, I'm just in and out, quick as I can really."* **H46MA**

At the other end of the scale were a number of users, mostly female, who viewed showering as an important and pleasurable undertaking. These participants often had grooming routines involving a number of stages and processes, which by necessity took longer than the perfunctory male users.

While some of these routines, particularly the washing and conditioning of longer hair, intrinsically took longer than their short haired counterparts, there was often a strong hedonic motivation behind their showering. Showering was a pleasure, an escape, something they looked forward to after a tough day.

> *"No, I wouldn't try and be quick. It wouldn't be something I would try and cut corners on or rush. I mean I'd reduce programs on the washing machine, but I wouldn't cut corners on that. I see it as a luxury, you know, a nice time that you can just hum away or whatever you want to do, and use nice products, that's my thing really."* **H45FA**

> *"Not really pampering, but yes I suppose it was relaxing. You know it was 9 times out of 10, any time I get to myself without them "Mommy" I just can't hear them in the shower. So I suppose it was relaxing time."* **H37FA**

This apparent gender difference in terms of attitudes towards showering and grooming, was not wholly surprising and indeed some of the participants commented to that effect.

> *"Women spend longer in the shower any way don't they, hair and that sort of thing."* **H43FA**

That is not to say that those who enjoyed longer showers were unaware of the associated environmental and cost impact, and were not conflicted to some extent by it. Indeed, some were extremely conscious that their showering practises had a high impact.

> *"If there was a big saving in having the device would you consider having something similar, even if it removed some of the relaxation from showering?"* **Interviewer**

"I wouldn't say no to it." **H45FA**
"Is that kind of, a sense of doing the right thing over the comfort of the shower or is it something else?" **Interviewer**
"We've always talk about it haven't we, getting rid of the dishwasher, we've traded in things consciously to reduce our impact haven't we?" **H45FA**

This conflict between opposing motivations clearly ties in to the goal-framing theory, where it is fully possible for different motivational goal frames to be active in the individual but for one to be dominant over others. In this case, the hedonic goal frame overrules concerns about cost and environmental impact that might be associated with gain or normative goal frames.

9.3.3 Sliding Scale of Behaviours

However, this motivational position alone did not fully determine the duration and nature of the participants showering. A concept stated by almost all participating families was that of the shower as the timeless space. This is obviously related to some contextual factors, such as the lack of clocks in the bathroom, as well as the difficulty in reading detailed displays while under a stream of water. In addition, the bathroom, and even more so the shower cubicle, is by design a private space, cut off from the eyes and ears of other occupants physically and also mentally. This isolation, combined with the highly sensory nature of the act of showering, makes it difficult to accurately connect with externalities such as time or energy consumption.

"I spend a lot of time in the shower." **H43mc**
"The bathroom seems to be a time zone of its own, whether its kindle reading or whatever you're doing" **H43MA**

"And would you have any, have had an idea of how long you spent in the shower before it came along and started giving you some feedback on that? Not something you've ever thought about?" **Interviewer**

"No." **H37FA**

Many of the participants spoke of drifting off and day-dreaming being frequent occurrences. At such times the cognitive focus of the individual is not on the immediate task at hand, i.e. showering, but has moved on to other topics. Even those who were highly motivated to minimise their time in the shower spoke of sometimes drifting off.

> *"No, it just made you realise how long you spent day dreaming in the shower and just wasting time doing nothing."* **H43FA**

This demonstrates the situational nature of the behaviour where the act is being unconsciously performed, and in many cases highly inefficiently. This is furthered by the fundamental physical pleasure of being in a warm, safe environment. The water will flow regardless of whether the user is actively using it to clean themselves, and if the user's focus is moved away from doing so the environmental impact can increase dramatically without any awareness on their part.

9.3.4 The Behavioural Role of the Intervention

By being automatic and initialising without the user having to switch it on, the feedback device fits closely to Fogg's (2007) concept of computers as 'always on' persuasive agents. As such, it inserts itself into the context without requiring the direct attention of the shower user. This is key in a behaviour space where, as shown above, the user's attention and cognitive focus can often drift elsewhere. In this sense, the device becomes a vocal non-human social actor (Nass & Moon 2000) in what has hitherto been a personal isolated space. A non-human social actor whose sole purpose is to refocus the user's attention to the act of showering and to how long they have been in there.

> *"I like the shades, I like the simple shades the pastel and I like the fact that it came to life and it was aware of what I was doing, and it was alive."* **H37MA**

Moreover, as the device was clearly presented as an energy reduction tool, its alerts were viewed in the context of reducing consumption i.e. not showering for long periods. Though obvious, this is a noteworthy consideration, as it positions the device's feedback in a moral normative context. This, in addition to the traffic light coding of the display and the progressively less pleasing audio feedback, makes clear the device's 'desire' to get the user to shower in an acceptably short time.

Thus when the device issues a sound alert, it is refocussing the user's attention to the act of efficient showering. In the context of the conceptual model, this has two main expressions. One is disrupting the consequences of the situationality of the behaviour, e.g. people drifting off. The other is activating a new goal frame in the user's mind to make them speed up or indeed finish. As this section will discuss, it is not solely normative or gain goal frames an intervention can activate, but a well-designed intervention can also engender hedonic goals in the user.

9.3.5 Breaking Situationality, Bringing Mindfulness

A number of participants remarked on how the automatic feedback of the device significantly increased their mindfulness of how long they had been in the shower and other associated efficiencies. This began as soon as the water was turned on and reached 35 degrees. At this point, the device lit up and chimed and drew attention to the fact that hot water was running. Several participants commented on this and explained how previous to the device arriving they would often have switched on the shower and possibly gone to do something else while waiting for it to get hot. This often caused hot water to run unused down the drain, as they were not aware that it had reached temperature.

> *"Yeah, that's one thing I just thought about, because before I would have just switched on the water and just get in after a while. But obviously when it beeps you know you're supposed to get in and I did."* **H46MA**

> *"Right and would you have done something else while you were waiting to the water to get warm, like have a shave or go to the toilet?" Interviewer*
> *"I would have done something until it was ready yeah."* ***H46MA***

As the shower progressed, the device would beep as it lit up a section at predetermined intervals (45 seconds for green, 25 seconds for orange and 20 seconds for red). These beeps often served to keep the participants focussed on the passing of time, and their proximity to the next colour section.

> *"I was always aware of the segment blip, that was always like "oh, segment bleep – better wash knees now."* ***H45MA***
> *"And MA you were always in the greens is that right?"* ***Interviewer***
> *"Yeah I tuned into the greens fairly quickly, at first I was in the oranges but I tuned in and got into the greens. As it moves up the legs, it beeps at each section, that worked for me."* ***H45MA***

When one 4.5 minutes had passed and the green section was fully lit up, 3 long 'klaxon' sounds were played which inserted themselves strongly into the consciousness of the users.

> *"When it turns yellow it goes 'BlupBlupBlup' and you just think 'Oh, Ok it's time to get out'."* ***H43fc***
> *"Yeah when it gets to the end of the green I think that's enough, I've done everything, time to get out."* ***H43mc***

> *"I think it's just the device being there, it acts as a reminder, reminding you how long you've been standing there. And you think "well the longer I'm standing here the more water, the more electricity I'm*

using". It gives you a sense to try and reduce that. And having had it taken out, I've missed it a bit." ***H45MA***

It was not just the increased duration of the sound alert which motivated the users and captured their attention, but it was also it's more startling and authoritative nature, which often alarmed the user and caused them to speed up.

.

"Sometimes if I'm, like, daydreaming in there and then it goes like Diu! Diu! Diu! because it's going on to the red and I think, oh God I need to get out of the shower." ***H40fc***

These alerts backed up by the visual display served to reprioritise the act of showering quickly in the consciousness of the participants. While this was not a universal reaction by all participants, it was however widely reported to be the case. As such, it strongly aligns with the Behavioural Intervention Selection Axis discussed above. In this case, the sound alerts are a spur-type intervention which disrupt the situational behaviour bringing it to a more reflective state. This disruption of situationality can be viewed as the intervention displaying a high degree of obtrusiveness, as per Zachrisson et al (2011). This is a dimension of behaviour change which appears to have a clear link to the level of situationality displayed in the behaviour. As originally proposed in section 5.3, the BISA aligns to a progressively increased level of intervention obtrusiveness, see Figure 9-4 below. Unlike Zachrisson et al's (2011) scale of obtrusiveness, the BISA recognises that a purely technologically agentive intervention, i.e. Clever Technology (Tang & Bhamra 2008b), would require a lower level of obtrusiveness. This is because such an intervention would achieve the desired aim without necessarily inserting itself so obtrusively. For example the Orbital shower (Orbital Showers 2015) is a new product which claims 80% efficiency gains by which captures, filters, and reuses hot water in the shower. This purely technologically agentive solution allows the user to shower for long periods without much of the associated impact, or any level of obtrusiveness.

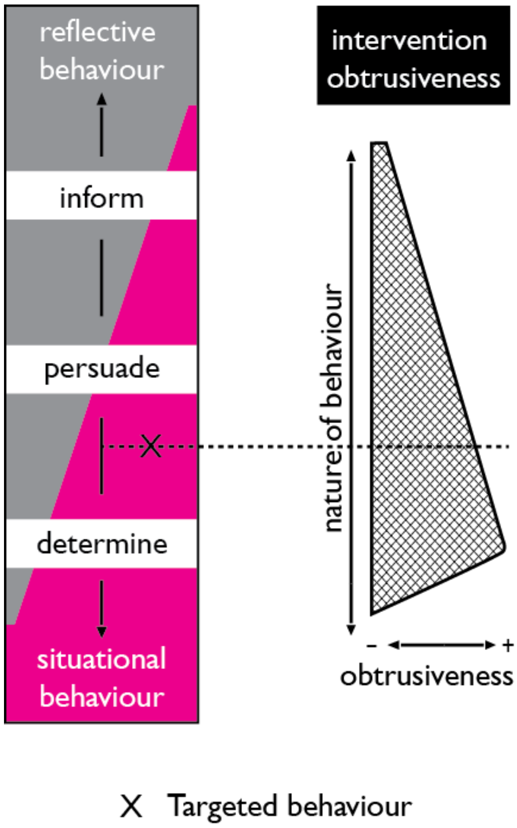


Figure 9-4. Required Intervention obtrusiveness.

It is important to note that such persuasive techniques seemed to have more effect on participants who regularly showered for more than 4.5 minutes (the orange section or higher).

9.3.6 Changing the Active Goal frame

As stated above, for many users showering was an intensely pleasurable activity, and was one they felt strongly about. These participants were aware of the conflict between their desire to save money and reduce energy consumption, and their enjoyment of their longer shower routines. In this context, the device's feedback was seen to refocus the user's attention away from the more pleasurable grooming routines to activate normative goal frames. As these are smart norms (Lindenberg & Steg 2007c),as opposed the purely social norms, they push the user to 'act appropriately'. In this case, this was defined as behaving in an environmentally less impactful way.

> *"It sort of brings certain "Agh, I'm using too much water" thoughts."* **H43mc**
> *"It did change, especially H43mc, who lives in the shower."* **H43FA**

However, that is not to say that the participant's awareness and desire for the hedonic showering routines dissipated entirely. Rather, by activating the normative goal frames, it placed them in conflict with the hedonic goal frames. This meant that for a number of participants, showering became a fraught emotional activity.

> *"I was quite horrified! It was very non-pleasurable! I was quite horrified, particularly when the sound came in I found it even more alarming. Partly because I didn't like the sounds you chose, I couldn't understand the choices at all. I just didn't like the more pressure of it really. But I suppose that's one of its functions really isn't. To make people slightly uncomfortable staying in the shower."* **H45FA**
> *"Well it didn't traumatise me beyond belief! I can cope with…ahm…I could..I could live with it yeah."* **H45FA**

Interestingly, and in line with the conceptual model, this did not result in a consistent new regime. Instead, there was still variation in the showering times reported by these participants and visible in the data. This relates to the temporal nature of decision making, while the device always brought the normative goal frames to their attention, there were times when the need and desire for a long pleasurable shower overtook them.

9.3.7 Attribution of Agency and Personality

One very interesting aspect of the trial was the amount of personality and emotion many participants attributed to the device. The device's automatic nature, the way it 'came to life' when the shower was turned on, the way that it expressed its pleasure or disappointment at the length of shower time, caused it to be seen as almost a living thing.

"I missed it a bit actually, it can be annoying a bit actually because I'm in the green so much that I get so used to the sound, {chuckling] but I kinda got fond of it." ***H45MA***
"It kept you company did it?" ***H45FA***
"Yeah, yeah." ***H45MA***

"The lights are actually nice and this sounds really artistic. I almost feel like I've got some company in the shower. When it had gone and I just got that white screen it's like I don't know whether you've ever watched Cast Away and there's Nelson, and when he first makes friends with Nelson, his trying to not go off the rails, but then when Nelson falls off the boat. Then you know you can really feel it, and yeah I had, I almost had Nelson with me." ***H37MA***
"Wilson." ***H37FA***
"Wilson, Wilson, Wilson, Wilson. Thank you." ***H37MA***
"So yeah, yeah I felt, I felt I really missed it. I missed the lights." ***H37FA***
"And what about it was the lights that you liked? Just that it kind of came to life when you were in there or just the colours and the?" ***Interviewer***
"I like the shades, I like the simple shades the pastel and I like the fact that it came to life and it was aware of what I was doing and it was alive almost to the point of if I went in there you know at dawn when it wasn't quite light outside I'd actually opt not to put the lights on and just enjoy that." ***H37MA***

While this is certainly a positive indication of the engagement of the participants with the device, it also has a deeper significance. The participants attributed a large degree of agency to the device; the positive feedback and fanfare were regarded as the praise they were intended to be, the increasingly less pleasant sounds were taken as judgement and disappointment. For some, the device was a friendly companion, others feared its ire. However by giving it this authority and recognising it as a social actor in the environment, these participants started to see the issue being not just about using less water and energy but about pleasing or beating the device itself. This relationship, like any social relationship, resulted in varied responses to the same motivational position. Sometimes the participants wanted to please the device, sometimes beat it, and sometimes they consciously and wilfully went against its dictates and enjoyed long showers. The dimension of emotion has been explored before in DfSB literature, it is one the Dimensions of Behaviour Change employed by Daae (2014), and has been most compellingly demonstrated by Lidman et al (2011) in their "Don't Drown the Frog" laundry dosing intervention. Both of the theses examples can be seen as examples of emotional design (Norman 2007; Jordan 2000) which target the behavioural concept of affect (Jackson 2005). While using positive emotion like this to drive behaviour change might seem that most appropriate path, the following section will show how it is just one of many emotionally charge responses which can be useful.

9.3.8 New Actors, New Goal frames

Because many of the participants started to treat the device as a social actor in the showering environment, one to which they were morally answerable, they developed a range of responses to it, which had not previously existed in this environment. These responses included:

- Competition
- Fear
- Guilt
- Contempt
- Desire for praise
- Avoidance of reproach
- Pleasure and fun

- Feelings of injustice
- Feelings of accountability
- Affection

These responses will be detailed below, but what is of particular note is how these responses fit into the conceptual model. Each of these responses is tied to a particular goal frame, in many cases a goal frame which was not relevant to the practise of showering prior to the introduction of the intervention. This confirms the position that the insertion of a DfSB intervention has an impact not just on the instrumental aspects of performing a behaviour, but also changes the motivational context. This change in motivational context is the key factor in any persuasive design.

Competitive Responses

Competitive responses to the device and its feedback were widespread amongst the participants. These can be classified as taking three main forms; competition with oneself, competition with the device, and competition with others. While it can be difficult to cleanly classify these different competitive responses, as there is an element of overlap and an inter-relationality between them, they provide useful lenses for examining the motivational role of the device.

Competition with Oneself

A number of participants stated that they were naturally competitive, and liked a challenge, and that their reaction to the device often took a competitive form. This can be seen to stem from the device's clearly expressed position of what is good behaviour, i.e. showering within the green section, what is acceptable behaviour, i.e. showering within the orange section, and what is unacceptable behaviour, i.e. showering within the red section. For these participants motivated by competition, these standards of behaviour became goals for them to achieve.

> *"That's interesting. As you probably know from interviewing us earlier on I like a challenge so this was just great for me 'cause it's like, "wow, okay, I gotta get in the green, I gotta get in the green!"* ***H37MA***

The responses differ between users for whom the challenge was to avoid bad behaviour i.e. the red section, and those who were already quite efficient and who were able to regularly finish their showering within the green. For those who struggled to take shorter showers, the competitiveness was necessarily set against the feedback delivered by the device. In these cases, it is hard to separate the personal ambition to be quicker and the feedback generating and shaping that. As such, these users will be further discussed under the heading Competition with the Device to differentiate them from those whose motivations were more internal.

> *"Yeah I do think they are, I did reduce my time, consciously, and I quite like a challenge. I got hacked off if I got into the red and I got the sound I didn't like, the "wahwahwahwaaah". So if I finished at the end of the yellows I'd get the better sound."* **H45FA**

For those efficient users, who had quickly been able to calibrate their showering time to be in the green section, the competitive motivation was an internal one. It was about seeing how much they could reduce their showering, and what was the quickest they could possibly do it.

> *"Most of the time yeah…I rarely didn't finish in the green…One time I tried to get one bar less and I was interested to see how quickly I could actually shower without scrimping on anything."* **H43MA**

These users however, were not fully supported by the device's feedback metrics, as they received no additional 'praise' or positive feedback for reducing their times further within the green section. As such, the sense of achievement gained diminished over time when no further challenges or rewards were presented to the participants.

> *"I first read that I thought oh well might be the green, might be the yellow occasionally I'm not sure actually. Of course it was green every time."* **H37MA**
> *"Every time?"* **Interviewer**

> *“Uhm so after about three showers I’d done that and I realized that I was always gonna be in the green.”* ***H37MA***

While these type of very efficient behaviours were not the primary target of the intervention design, it does illustrate the importance of accommodating both efficient and less-efficient users in the design. A fully sliding scale of challenges and/or rewards should be incorporated into future DfSB interventions, e.g. a different finishing sound for each segment in the green section. This would further support these users’ ambitions.

> *“I haven’t heard that many showers with that on because you know the two just above that. I’m pretty sure it was always green for me, I am pretty sure, and the fanfare.”* ***H40MA***
> *“Yeah, and the fanfare. You weren’t a fan of the fanfare.”* ***Interviewer***
> *“No, the fanfare is okay, it would be nice to have it somehow varied.”* ***H40MA***

> *“And did you think it has any effects on you? Do you think you sped up?”* ***Interviewer***
> *“Yeah, no, um, not with me I’m comfortably in the green so, yes, yeah.”* ***H46MA***

Competition with the Device

As the device set the boundaries for what was good or bad behaviour, and consistently provided supporting feedback to this effect, it became the focus of some participants competitive natures. Participants sought ways of ‘beating’ the device or evading its negative feedback from the red section. While the net result of these actions was often a reduction in time spent, and thus resource consumption, this was not necessarily the primary motivation of the participants. These participants were primarily motivated by avoiding the negative feedback, rather than solely behaving appropriately.

> *"For me it's been good, it's motivated me to get out quicker. And because I'm competitive I don't like to be beaten."* ***H43FA***
>
> *"I think, for me, it represented a bit of fun, it was interesting but it did make me want to shower less in the shower just to compete with it. So it was good, but I'm a reward incentive based person in just about anything."* ***H43MA***
>
> *"I was aware of the time running out and you automatically try to beat the clock, isn't it? So yes it did rush me a bit, in a good way."* ***H40FA***

Further illustrating this point, a number of participants spoke of "cheating" the device or using a range of different strategies to squeeze more showering time out the same number of sections. These hacks included getting in before the 'water is hot' alert, cutting out elements of their routines and running cold water at the end of the shower to remove any lag.

> *"Yeah, but I thought it was ready before it beeped…..And I thought I'd get a little bit longer in the shower before it turned red!"* ***H45FA***
>
> *"I just turn it on and dance around until it's the right temperature [laughter]. So I wouldn't run the shower first so the beep had no effect on me. Sometimes I could beat it and be under the water before it came on! Not that I'm competitive or anything [laughter]."* ***H43FA***

For these participants, successfully squeezing the margins and getting the desired feedback was the key motivator.

Competition with Others

Obviously the family home is not an isolated space, but instead a space of deep interaction between the occupants and the larger society. As a new arrival in the home, the device created some conversation around the topic between the occupants but its more instrumental effect was seen when it started to be used. While it would be overstating the fact to say that the device created a frenzy of inter-family member competitiveness to see who could achieve the lowest score, it did in some cases provide a social motivation.

For those who were efficient users, this could be seen as a form of validation providing a motivational boost to their efforts. However, the effect is probably more important to those who were not as quick, as it provided a very personal benchmark to compare to.

> *"No, I'm probably the quickest, as we found out when we got competitive in the first couple of weeks! Even with a hair wash, so that was useful from that point of view."* ***H43MA***
> *"H43MA went "Oh, you got up to red on your shower!" O Pious One!"* ***H43FA***

It appears that in the cases where this sort of dialog existed, the competition between family members reduced after a relatively short time. Participants seemed to accept their own level as being different to other family members, and not on the same competitive playing field.

> *"Oh I don't know I remember some green challenge moments between you two boys, and about how I never got a green."* ***H45FA***

New Goal frames derived from Competitive Behaviour

This sense of competition with the device creates a new hedonic opportunity, when a participant is successful in avoiding the negative feedback they are pleased with themselves. This is becomes a new motivational force derived primarily from the attribution of agency to the device.

> *"And so you're describing it as a ticking time bomb, is that how it felt?"* ***Interviewer***

> *"Well yeah, to begin with, but you get used to it in the shower and you start to feel quite smug if you got between a certain time."* **H45FA**

This is a very interesting development, where previously the only hedonic goal frame mentioned in relation to showering was of the sensory pleasure and 'me time' that went with it, now the device is mediating a new hedonic goal frame. Hitherto, most pro-environmental behaviours would have generally been driven by either an active gain goal frame or an active normative goal frame. This illustrates that an appropriately designed DfSB intervention has the ability to substitute the pleasure of consumption with a pleasure derived from the reduction of resource consumption.

Emotional Responses

Fear

While most participants viewed the device as a piece of technology designed to give them feedback on the duration of their showers, for a couple of participants the device took on a more vivid and powerful character. This is certainly related to the negative feedback being seen as castigation, which was so unwelcome as to create a very strong desire to avoid it, verging on fear.

> *"I was very persuaded to have a really quick shower! [Laughter] The first time I was in there I literally went half way through the green, and then I got back out again! I was really scared that it would, like, really beep at me or something if I got to yellow! [Laughter]"* **H43fc**

Guilt

Where previous to the introduction of the intervention the actual duration of a long shower was unlikely to have been recorded or relayed, during the trial the device not only provided feedback on the duration, but also categorised it as good or bad behaviour. For some participants, being shown how long they had showered for gave rise to feelings of guilt.

"No I feel guilty when it goes to yellow." ***H43fc***
"I felt guilty for that [when speaking about a full red shower]." ***H43mc***

The association of guilt with having a shower is a new development in the context of this behaviour, and one created by the intervention. Such guilt acts to bolster the motivation of the user to achieve lower times and this is an important part of the emotional make-up of the active goal frames. However, it is important to note that were an intervention to continuously engender feelings of guilt, it is likely that the users would disengage.

Contempt

There were isolated moments where the user's hedonic motivation to have a long shower (often to recover from prolonged exposure to cold e.g. playing sports outside) clashed with the fixed feedback categories of the device, leading to a sense of contempt or disregard for the device. In these cases, the device made no allowance for the reasonable need to warm up and have a long shower, and so the users rejected any moral authority it may have had. Once the users had crossed into the red section they had gone past the point of no return as far as they were concerned.

"You know when he's (H46mc1) been to football and he comes home, he's been wet, he's cold and he'll sit and let the warm water over him." ***H46FA2***
"I didn't like it when it said I'd done bad. I'd say I did not do bad I did quite well actually." ***H46mc1***

"Yeah I was, I was. And sometimes it's a bit of a struggle, I really don't want to get out, but I really don't want it to go to red! …But by the time it got to red, I thought "Well, I've lost anyway I might as well stay in. So actually by the time I got red I thought "I can't be bothered now I might as well stay in for longer." ***H43FA***
"Past the point of no return." ***H43MA***

While these participants continued to engage with the device after these events, showing that they were temporally isolated, it does provide an important lesson. If an intervention consistently derides a reasonable user need, it will in fact compound the negative effect of the target behaviour.

Desire for Praise

The design of the intervention aimed to provide positive feedback for shorter showers. It was hoped that the participants would see this positive feedback as praise from the device and in some incidences this proved true.

> *"The red is a bad thing! Yellow's fine, because it still played me a happy tune if I finished in orange! I figured it was still cheering me if I had full orange, so if that's alright for the machine then I staying in! ."* ***H43FA***

Avoidance of Reproach

The flip side of participants' desire for praise was perhaps even more powerful, and this was an avoidance of negative feedback. As mentioned in the section on contempt (above), the negative feedback was a powerful tool. Those participants who struggled to shorten their showering routine and who were consistently between orange and red, exhibited the greatest focus on avoiding the negative feedback.

> *"I didn't want to go to red because it was…"* ***H43FA***
> *"It was disappointed."* ***H43mc***
> *"Yeah it was disappointed! [Laughter]"* ***H43FA***
> *"It shakes it head and points its finger!"* ***H43mc***
> *"Yeah, it should do shouldn't it!"* ***H43FA***
> *"So those noises obviously had an effect?"* ***Interviewer***
> *"They did!"* ***H43fc***
> *"They did, I hate to say it but they did…I hate to think that I was that swayed by little lights and noises, but I really was!"* ***H43FA***

Pleasure and Fun

While the intervention was created to curtail an often pleasurable behaviour, it was not seen universally as a joyless entity. For many participants, indeed the majority of the sample, the positive feedback given for finishing in the green or orange sections was seen as a pleasurable affirmation of having behaved well. While this was particularly true of children, who could be seen to be more swayed by the fan-fares and applauses of the earlier finishing times, it was also true of many of the adults. This pleasure may have been derived from elements of social and personal competitiveness (outlined above), but it also stands alone as a reaction to being rewarded with praise.

> *"I think, for me, it represented a bit of fun, it was interesting but it did make me want to shower less in the shower just to compete with it."* ***H43MA***

For the more efficient users who almost always finished in the green section, the sense of reward did diminish with time, and in some cases the noises became slightly irritating, but this appears to be more linked to the fact that the same reward sound was repeated every time.

> *"I missed it a bit actually, it can be annoying a bit actually because I'm in the green so much that I get so used to the sound {chuckling} but I kinda got fond of it."* ***H45MA***

As well as the intended feedback based rewards, the device also brought a sense of fun to the experience, particularly for younger participants. The device brought a level of theatre and activity to the act of showering, which was entirely novel, and its arrival piqued the curiosity of all the younger participants. This curiosity extended as far as many of the participants exploring the full range of noises and colours when the device arrived.

> *"And girls what did you think about the look of this when it arrived?"* ***Interviewer***
> *"Uhm, it was exciting."* ***H37fc1***

"To get something new?" ***Interviewer***
"I liked the noises." ***H37fc2***

While there may obviously have been a couple of longer than necessary showers in order for these participants to explore the full range of feedback, any impact from this is outweighed by the participants then being able to contextualise their own results, and the sense of engagement that this exploration generated. As such, the ability to explore the bounds of any DfSB intervention without fear of undue consequences is key.

Feelings of Injustice

Participants spoke of feeling cheated by the device when the temperature lag would cause the counter to keep going after the shower was turn off. This was due to a technical limitation of the intervention prototype, which relied on a thermistor cooling to below 35 degrees before registering that the shower was finished. The lag between turning off the flow of water and the device registering that event ranged between 5 seconds and 90 seconds. If this lag carried the device into the next section the participants would get a worse feedback sound than they deserved.

"Also when you switched of the shower, sometimes the drips would keep it going for a while afterwards." ***H45MA***
"Yeah I felt cheated a few times! It incremented another chunk and I got the horrible noise instead of the good noise." ***H45FA***

Obviously any feedback intervention should be wholly accurate and this lag effect is considered very undesirable. However, the users had been warned of the possibility of it happening, and so were prepared somewhat for it. As can be seen above, this did not wholly mitigate those feelings of injustice when it occurred.

It is conceivable that this inconsistency in the device may actually have acted as a motivation feature, that the disappointment of being "cheated" made the occasions when the correct, more positive feedback was received more pleasing to the participant.

This could align to theories of operant conditioning and the role of random rewards (Weinschenk 2011) and is an interesting angle for future research to consider.

Feelings of Accountability

What might be considered one of the strongest motivational aspects of the intervention was the sense of accountability the participants felt towards the device. Obviously by agreeing to take part in the trial and having had regular contact with the LEEDR team for over a year, there is a case to say that such accountability to the device is bound to a sense of accountability to the LEEDR aims at large. Participants were questioned to this effect, as to whether their efforts to reduce their showering times (if there had been any) were linked to a desire to help the research project or whether their efforts had been a direct response to the unit at the time of use. While such a question cannot be expected to give a definite answer, it did cause participants to reflect and give a considered response.

For the most part, most acknowledged that there would have been a desire to try to engage with device because of a sense of obligation to the researchers. However, nearly all participants stated that any actual changes in their behaviour were due to the intervention's feedback.

> *"It did, but I'm not sure how much of it was because it was part of your study, or whether I would spend that little time if I didn't have to answer to you….I didn't feel obliged, I didn't feel obliged to get out of the shower because you were doing the study. I didn't feel like I needed to, I felt like I needed to beat the machine! If you see what I mean, It's hard to actually make sense of it."* **H43FA**

More than this, and linked to the attribution of moral agency to the device that many participants spoke of, they felt accountable to the device for their actions. They felt the device was in charge, and that the showering durations it proposed to them were reasonable and should be followed. Perhaps of significance in this feeling of accountability was the knowledge that the device was recording the shower times. This can be considered a form of surveillance (Lockton 2010), which is shown to be a very persuasive instrument. The knowledge that their times were being recorded and would be seen by other family members, proved an important motivator in cases where the hedonic pleasure of showering had overruled the persuasive prompts of the device.

> *"And what would motivate you to be quicker then? Is it because the device is recording or just because you know you should be trying for a certain amount time?"*
> ***Interviewer***
> *"Probably because it was recording them ... You're sort of comparing it to everybody else's right after."*
> ***H37FA***

Affection

A number of participants expressed a high level of affection for the device. Interestingly, these were all people who regularly finished showering within the green section, thus their relationship with the device was one of positive affirmation. Because their existing practices were by and large in line with the dictates of the device, they did not find using it as challenging as those that had longer showering practises. This meant that several of the participants commented on how much they missed the device when the trial was over, and when pressed on this explained that the device had become a companion for them during an otherwise solitary activity.

> *"I almost feel like I've got some company in the shower… I felt I really missed it. I missed the lights."*
> ***H37MA***

> *"If you had to describe it in one word?"* ***Interviewer***
> *"Clunky Companion, I thought. I bonded with my Shower Maggot, it was quite good."* ***H43MA***
> *"Are you looking forward to it being gone? Well its gone already I suppose in that it's stopped working."*
> ***Interviewer***

“Yeah I’ll miss it, I thought we were going to keep it.”
H43MA

New Goal frames derived from Emotional Responses

The rich emotional responses the participants experienced create a new layer of motivational opportunities. These responses are generated by interaction with the intervention and did not exist in the context of showering prior to its arrival. This is a significant finding as it shows how the relationships people develop with technology impact on their motivational goal frames driving behaviour.

Where previously the main hedonic goal frame linked to showering was the pleasure of enjoying a long soak, we now see participants getting pleasure from receiving praise from the device, from having fun, from positive affirmation of good practices, and from the affection they felt for the device.

Similarly, the sense of accountability to the device, guilt, and the avoidance of reproach from it, indicate a new normative goal frame taking shape. Showering behaviours which would have escaped this normative lens in the past, are now called into question by the device and subsequently the user.

This shows that it is within the means of the designer to develop a new emotional relationship between the user and the target behaviour through the utilisation of persuasive techniques. This can create a situation where users are actively trying to ‘please’ an intervention by undertaking a behaviour which it ‘condones’. This relies on the intervention having a perceived moral agency and that being broadly in line with the users. It also relies on the device not being passive but independently displaying some qualities of a living organism. In this case these include; automaticity, acknowledgment of the user, audio visual communication, a moral stance, and some anthropomorphic features.

9.3.9 Deep Situationality of Showering

When the trial was over, the devices were allowed to run out of batteries and remain in the participants homes for another one or two weeks. This was done to assess if the device had had a perpetuating effect on the showering times of the participants, in short, had it led to the creation of new, more sustainable habits. While Lally et al (2010) had indicated that new habits could be formed in 66 days, in reality that study produced a wide range of results between 28 days and a projection of 284 days. Furthermore, this study focussed on the generation of a new behaviour (in this case a positive health change, like eating fruit), which differed to the aim of this intervention trial which was to curtail an existing behaviour, i.e. showering for a long time. In any event, it was not possible to trial the active feedback device for 66 days but it was active in the participants' homes for between 7 and 8 weeks.

When asked had their showering routines changed since the departure of the device, most of the participants who had had the longer showering routines commented that they were more relaxed and less concerned about time since it departed. Some felt they had increased the length of their showers as soon as the device was removed, and another who had gone to great efforts to shorten her showering time by removing and cutting some elements of her routine, had reintroduced them shortly after the device was removed.

> *"Now that the device is gone from your shower have you gone back to brushing your teeth in the shower or have you kept the shorter routine?"* ***Interviewer***
> *"I did to begin with but now we've just come back from holiday and I went straight back to brushing them in the shower. I am aware of that because it probably adds a minute or something."* ***H45FA***

While it was not possible to measure the showering times after the device was removed, it appears likely that for a good number of participants they increased. This indicates firstly that a sustaining habit of shorter showers was not developed, which is not wholly unsurprising. Asides from the relative shortness of the trial, habit by definition is formed through context-dependent repetition. The intervention device was the contextual feature prompting the pro-environmental behaviours, and its removal would have taken away those behavioural cues. However, it is not believed that a longer duration trial would have eventually given root to a sustaining habit for shorter showers. This is due to the deep situationality and timeless quality of showering, combined with the hedonic aspects of it. As one of the most common reasons for longer showers given was lack of mindfulness or awareness of time, these problems remain in place in the participants bathrooms. Continuous heating hot water boilers combined with the privacy a lack of time devices or connection with the rest of the household, facilitate longer showering without awareness. As such, it is likely that such a contextual set up would require an active intervention of some sort to increase users' mindfulness and spur them towards shorter showering durations. This is in line with other research which indicates that *'behaviour returns to baseline if the source of motivation is withdrawn'* (Lehman & Geller 2004)

9.4 Intervention Selection Tool for DfSB

It should be stated that a central tenet of the author's approach in creating the conceptual model and subsequent BISA was that the information be presented in a form that would be understandable for designers to actually use in practice. As a visual discipline, it made sense that the concepts be presented as visually as possible. In addition, a paucity and simplicity of verbal descriptors were considered to be important in terms of providing an effective tool. Since the creation of the original DfSB axis of influence (Lilley 2009), the elegant simplicity of the model has been reduced as a number of researchers have tried to include more and more of the elements of behaviour and intervention strategy. Though indeed the author could be accused of the same, a concerted effort has been made to retain a high level of simplicity and clarity, while introducing useful and relevant concepts.

As shown in the literature review, Boks (2012) has highlighted a significant gap in DfSB literature relating to the need for more support as to when to select which intervention strategy. This is an area that had already been explored by a number of authors (Lilley 2007; Tang & Bhamra 2008b; Renström et al. 2012), but as the literature review has shown, there remained significant challenges in the implementation of these. A considerable amount of research has been conducted by Johannes Daae (previously Zachrisson) who has focussed on the development of an intervention selection tool for designers (Zachrisson & Boks 2010; Daae & Boks 2014; Daae 2014; Zachrisson et al. 2011). Daae's investigations began with a simple selection matrix comparing user attitude towards the target behaviour against the level of agency of the intervention approach. This was expanded further into the Design Guide for DfSB (Zachrisson et al. 2011), which added the dimensions of Habit, Intentions & Constraints, Values and Norms, and Importance/Annoyance. Implementation of these models exposed a number of limitations in them; primarily that the multitude of dimensions and relevant intervention strategies often led to the proposal of conflicting intervention strategies for the same user and the same behaviour.

Further work by Daae sought to address these issues by providing a step by step guide for how to apply them. This was termed the Principles of Behaviour Change (Daae 2014), however several workshop based evaluations and subsequent iterations showed that designers strongly rejected such a rigid linear approach. It has been shown before (Lofthouse 2006) that designers dislike and avoid using tools which are overly prescriptive in their application. This is because designers tend to work in a manner individual to themselves which is rarely linear (ibid). In response to this, Daae (2014) created a design tool called the Dimensions of Behaviour Change. This tool comprises of a set of eleven cards "presenting dimensions for how your users will experience your design and the design principles you apply". The tool can be viewed more as an inspiration tool akin to Lockton's (2010) Design with Intent cards, rather than an intervention selection tool per se. This is because using the tool leads to the generation of a wide range of concepts rather than a single considered direction. However it must be stated that Daae has developed this model through a rigorous and iterative process of evaluation with an array of design practitioners, ranging from students to professionals. This lends it a high degree of credibility as a design tool, albeit one which does not necessarily aid the selection of a final intervention strategy.

In contrast, the Behavioural Intervention Selection Axis (BISA) presented in this thesis maintains an intentionally simplified approach. It primarily provides guidance for the selection of intervention strategies based on the level of situationality expressed by the users' behaviours. The intervention strategies it proposes are kept to a very high level, allowing for a very wide range of possible interpretation by designers. Uniquely amongst DfSB models it acknowledges the fact that a new intervention disrupts the existing behaviour and can require auxiliary strategies to guide this new behavioural state. The model also incorporates Daae's (2014) concept of obtrusiveness and aligns it against the axis of intervention agency. Importantly however the BISA recognises that the required level of obtrusiveness diminishes significantly when highly technologically agentive interventions are employed.

This simplification should not be seen as a weakness, but rather a more accurate reflection of the needs and capabilities of the designers it was created for. Every behavioural situation is influenced by a vast number of often unique factors. Rather than trying to account for all of these in a selection tool, it is wiser to allow the designer's empathic awareness of the key factors to dictate the final form and configuration of any intervention approach.

The BISA has been shown to be a useful tool both in generating interventions for this research, and also as tested in the workshops described in Chapter 7. It has been shown to have achieved three of Lindahl's (2005) characteristics for successful design tools. The fourth characteristic, "that the use of the method or tool must reduce the total calendar time to solve the task", was untestable within the constraints of this research. To do so would require a sizable group of design practitioners who have previous experience of employing DfSB methods to use the BISA to guide a full intervention design process from start to finish. The BISA, as developed and tested in this research, has not been packaged into a comprehensive toolkit as per Lofthouse's (2006) recommendations. It was considered more useful to evaluate the core theoretical implications of the BISA and their usefulness in application for designers. This may, however, be something to consider in future work.

9.5 Innovative Artefact

Though positioned as a case study in the context of this research, the intervention design has led to the creation of an artefact innovative in its own right. The final design was heavily constrained by the need to produce a number of working prototypes, and this had a negative impact on the final functionality and aesthetics of the unit. These, however, are factors which could easily be addressed through further development. Chapter 7 intentionally avoided representing the effect of the device as mean reduction in showering duration across the sample as it was felt that this was overly reductive. What was considered to be more enlightening was graphically representing the nature of the change in behaviour over time through scatter plots and comparative bar charts. These showed that the device caused participants with longer shower routines to reduce them to a more acceptable duration. This was a duration acceptable to them given the motivational nature of their own showering routines.

The device, even in its *"clunky"* prototype form did have a significant effect on over all showering time. The average baseline time recorded in the five households where the intervention functioned reliably was 5 minutes 25 seconds for all shower events. For the period that the device actively gave persuasive feedback the average time fell to 4 minutes even. This equates to an overall reduction in average showering time of 26%, a sizable saving by any standard. This is not a statistically valid number, and cannot be seen as being representative of the device's potential impact on the population at large, but it does indicate that the device has great potential to effect a wider change in consumption in this area. It shows that the general configuration and the nature of the persuasive methods employed are effective on some users and should be developed further.

As this intervention was a Path 2 (Renström et al, 2013) approach, involving the introduction of an auxiliary piece of technology to mediate behaviour, it was necessarily limited in the amount of agency it had over the entire showering practice. For example, it could not turn the water off of its own accord, nor moderate the flow rate. This type of approach is, however, the most realistic for intervention at a national level. It is relatively cheap, and does not require major changes to the existing infrastructure.

Given this, it is worth reviewing the design of the unit with a view to further iteration, in line with the HCD approach (IDEO, 2009). What follows is a list of recommended changes to the design of such a device, based on its functional performance and on the desires expressed by the participants.

The two largest complaints the participants had related to the physical size of the device, and the time lag between the water being turned off and the device registering the event. The size of the unit was driven by the three large batteries required to power it for a meaningful period of time, and the lag was due to an imperfect technical solution using a thermistor to register the flow of hot water. Both of these issues could be solved with the introduction of an inline turbine, which would be connected to the shower hose. Such a turbine would accurately register the flow, while also generating enough power to run any electrical feedback system, with very little impact on water flow. A visualisation of such a product configuration can be seen in Figure 9-5 below.

Figure 9-5. Revised Enuf concept with in-line turbine power.

The turbine would also allow for dramatically reduced power consumption as it would be switched on by the shower flow negating the need for the device to be constantly on and monitoring temperature every second. This mechanical switching due to water flow would also allow for the reduction of the threshold temperature from 35° to a more inclusive 28° which would negate the issues experienced in H28. This higher temperature was originally needed to ensure the ambient temperature of a sunny room on a hot day would not trigger the device.

One negative mentioned by many of the users, particularly those who finished in the green section regularly, was the repetition of the finishing sounds. Any future device should come pre-programmed with a range of sounds for each finishing time to provide variety and long-term engagement.

Furthermore, while the participants had responded to the device's instantaneous feedback, many expressed a desire to see more data and in particular, more comparative data. The effectiveness of this approach was further illustrated when the participants were shown the plotted graphs of their results at the end of the interviews. It is recommended that any future such intervention be able to communicate such data wirelessly to a larger feedback system. The frequency, metrics, and form of any secondary feedback would need to be refined through further user testing.

9.6 Drivers behind Showering Behaviours

In a substantial review of the environmental impacts of showering and bathing, Walker (2009b) identified the need for research to investigate the drivers behind showering behaviours.

> *"Identifying the drivers of behaviour may in turn help to underpin a discussion of the most effective means of achieving behavioural change in personal washing, in particular individuals reducing the duration of showers."* (Walker 2009b)

One of the emergent findings uncovered in the implementation of the intervention case study was an insight into these drivers as expressed by the participants. These have been discussed in detail in section 6.4 but will be summarised below.

Hygiene – the primary driver behind showering behaviours can be seen to be a normative one. That is to maintain a socially acceptable level of hygiene. This can be seen to dictate the frequency with which people shower, but does not necessarily explain the durations.

Pleasure – an intrinsically hedonic motivation for many people, showering has many pleasurable aspects. In some cases this can be seen to be a question of self-image, somewhat mediated by a normative goal frame, i.e. feeling good about themselves because they are maintaining a socially acceptable level of hygiene. In many cases however this pleasure is simply derived from the experience of relaxing under hot water in a private space.

Waking Up – as showering is commonly part of people's morning routine, it was often seen as a gentle and comforting way in which to 'wake up' and face the day. This is driven by the hedonic aspects of using warm water but displays the characteristics of a deeply situational behaviour.

Daydreaming – for many the privacy and warmth of having a hot shower was a pleasurable experience which facilitated them in daydreaming or reflecting on aspects of their life external to showering. For some this was a recognised part of their showering routine where they would plan events for the upcoming day etc.

Efficient Users – many people see showering as a functional necessity, one which must be performed but in the quickest time possible. While these people are still occasionally susceptible to situational aspects of the behaviour like daydreaming, their primary goal is gain based. They want to free up time for other productive activities.

Wasteful Behaviours – there are some aspects of showering which are consequences of the technical affordances of the system rather than the individual's intentionality. The fact that the water must be run for a while before reaching the desired temperature means that many people turn on the water and go off and complete other tasks, e.g. going to toilet or brushing teeth. This can lead to significant quantities of water being wasted.

Recently other researchers in this area have investigated showering behaviours. A large survey conducted by Renström & Rahe (2013) identified the increased environmental impact that the hedonic drivers in particular have on showering behaviours. It is worth noting that this study analysed behaviour through the lens of goal framing theory, and that their findings are largely in line with those mentioned above.

Other researchers have viewed showering through the lens of practice theory. Chappells and Shove (2005) view showering practices as a socio-cultural construct. That is to say that both the nature and frequency of showering are driven by socially shared values which in turn are shaped by available technologies. This certainly has some validity in the scope of this research, especially in the cases of those with routinized grooming behaviours, such as hair washing and conditioning, body scrubs etc.

Kuijer & Jong (2011) have taken this concept of showering practice and tried to reshape it through the complete reconfiguration of the primary technology involved. They propose replacing the shower with a containment vessel and seat which would allow the user to remain comfortable while cleaning themselves through the less environmentally impactful means of a sponge bath. While this would certainly reduce the environmental impact and go some way to addressing some of the hedonic motivations driving showering behaviour, it remains to be seen whether such a solution would be considered convenient or desirable. Furthermore such a proposal requires the replacing of the existing shower unit with completely new technology, something which would take a considerable level of investment.

In contrast, the intervention put forward in this thesis could be readily retrofitted to existing showers. It does however have some very strong limitations in terms of the maximum reduction in consumption that it could effect. Socially shared practices, for example hair care routines, can be reduced in time but not eliminated. This indicates that behavioural intervention alone may not be sufficient to effect the desired reduction in every case, and that practice level intervention (Kuijer & Jong 2009) has a very valid role to play notwithstanding the significant challenges it presents.

It must be noted however, that the drivers listed above are those expressed by the participants before the introduction of the intervention. The intervention itself gave rise to a host of other motivational drivers which had a significant impact on how the participants viewed showering. This is of key significance when considering possible intervention approaches to any behaviour; the *existing* drivers reflect the *existing* situation, an intervention *changes* the situation and can give rise to *new drivers.*

10. Conclusions and Future Work

10.1 Introduction

In this final chapter of the thesis, the overall findings of the PhD are presented. The first section confirms the achievement of the research aims and objectives. The next section details the general conclusions derived from the research activities presented in the previous chapters. The limitations to the findings are discussed in section 10.5. The chapter culminates with a discussion of future work which could build on the findings and further advance the study area.

10.2 Achievement of Research Aims & Objectives

The aim of this research was to determine effective strategies for the design of interventions that engender reduced energy consumption through behavioural change. This aim has been achieved through the successful completion of the following research objectives, detailed below.

1)To identify the determinants of user behaviour through the evaluation of established behavioural theories from existing literature.

A comprehensive review of the relevant literature was undertaken in Chapter 2. This identified a number of key behavioural determinants and theories which were used to frame subsequent research activities. In addition, a number of gaps in DfSB knowledge were identified, which went on to inform and focus subsequent research activities.

2) To develop the findings of the literature review into a conceptual model of behaviour in context.

A novel conceptual model of behaviour in context was developed from the literature and described in section 2.7. This conceptual model was used to frame and guide subsequent research activities.

3) To gather domestic energy behaviour data through a qualitative contextual study of real people.

Chapter 4 details the comprehensive User Study that was undertaken in context with 20 participating households. It used a range of methods, some established and some novel, to gather a large quantity of information on the many factors which constitute domestic energy behaviour.

4) To test the role of the conceptual model through the analysis of the qualitative contextual study.

The conceptual model was tested against the findings of the User Study in Chapter 4, which showed that it provided a salient and useful description of the various factors which constitute behaviour.

5) To develop a reliable Design for Sustainable Behaviour intervention selection axis.

The findings of the User Study and literature review were drawn on to create the Behavioural Intervention Selection Axis (BISA) in Chapter 4. The reliability of the BISA was shown through the subsequent intervention development and evaluation documented in Chapters 5 and 6.

6) To concurrently test the Design for Sustainable Behaviour intervention selection axis suitability for use by designers.

The suitability of the BISA for use by designers was tested through two means; firstly by being used by the author in the development of the interventions outlined in Chapter 6, and secondly through a series of design workshops conducted with student designers described in Chapter 8.

7) To create a Design for Sustainable Behaviour driven prototype targeting reduced domestic energy consumption.

A fully functioning DfSB intervention was designed and developed, as outlined in Chapter 6. This intervention sought to reduce the occurrence of longer showers thereby reducing related energy consumption.

8) To test if the design interventions have been successful in reducing energy consumption though a combination of quantitative energy use measurements and qualitative contextual study.

As described in Chapter 6, a medium term field trial was undertaken in 6 participating households, employing 9 functional intervention prototypes. These recorded quantitative use data during their deployment, which shows a clear and substantial reduction in overall energy consumption across the sample. Further qualitative investigation, taking the form of group interviews, illuminated the nature of the behavioural responses of the participants, and the reasons behind them.

10.3 Overall Conclusions

From the beginning this research project has been grounded in the field of DfSB. This is a relatively new and rapidly growing research field which exhibits great promise as a means of achieving the reduction in energy consumption and related CO2 emissions required by international treaty. Early on in the research a number of gaps in the knowledge were identified, which the research activities undertaken sought to address.

As DfSB is a field which seeks to change unsustainable behaviours to ones with a reduced social and environmental impact, it follows that one must first understand the behaviour in order to do so. Human behaviour is complex and multifaceted, and subject to a large number of external and internal factors. This has led to the proliferation of complex models of behaviour, none of which can be said to be fully definitive. Given this, it stands to reason that the most appropriate behavioural model to guide DfSB is not necessarily the most comprehensive, but is the one which proves most useful for designers to follow. This was the reasoning behind the generation of the conceptual framework, which employs goal framing theory (Lindenberg & Steg 2007). Goal framing theory describes behaviour in readily understood human terms and, as shown throughout this research, is easy for the designer to apply to the type of research outputs generated in design investigation. In this sense it can be said to be more useful than previous models employed within the field (e.g. Bhamra et al. 2008; Zachrisson & Boks 2012), and has been proven to work in the context of this research.

The lack of a reliable method of selecting intervention strategies for DfSB has long been a problem in the field. Various theories as to how and when different intervention strategies should be used have been put forward through the years, but none has been shown to be reliable. As the field has developed, these selection strategies have tended to increase in complexity in an effort to better describe the expanding knowledge base. However, in so doing they have become unwieldy and unappealing to practicing designers. In the specification of the BISA in this research, a decision was made to focus only on the core dimensions of DfSB intervention strategies and to place them in a simple open framework. This has kept the BISA easy to understand and employ, as shown through its use in developing the interventions and subsequent evaluation with student designers. More importantly, however, the central construct of the BISA; that of aligning the level of agency of the intervention to the level of situationality displayed in the behaviour, has been shown to work reliably within the context of this research.

Considerable time and resources were invested in the design, development and production of functional intervention prototypes. This was done in an effort to redress the remarkable lack of DfSB case studies which demonstrate a medium-to-long term reduction in energy consumption. In some respects this was a gamble as a significant weight of the validation of the conceptual model and BISA was placed on the intervention performing as intended. However it was felt that this was a necessary risk as any theoretical development can only be shown to be truly useful if it is effective in practice.

The intervention case study described in this thesis has helped validate the theoretical developments but has also produced interesting findings in the area of showering practices. It has shown how in many cases that personal hygiene is a background motivation in many people's showering practices. It has also provided rich insight into the effect a persuasive feedback device can have on a user's active motivational frames. Where previously showering may have been a pleasurable or deeply situational activity, the intervention when active brought a whole new range of motivational factors to the fore.

10.4 Contribution to Knowledge

Design for Sustainable Behaviour is a young and rapidly developing field. As such, the theories underpinning it are not yet fixed and defined but are still being formed. Since the beginning of this research journey there has been considerable development in the field, with major work being done on evaluation methods (Wilson 2013), intervention strategy classification (Renström et al. 2012) and the dimensions of behaviour change (Daae 2014) to name a few. However from the outset this research had identified a number of gaps in the knowledge which have hitherto not been addressed in the literature. The following section outlines these and how this research has contributed to the field in these areas.

In the review of the literature pertaining to the field, the need for a reliable intervention selection model that could be used by designers seeking to change behaviour in the field of DfSB was identified. In seeking to create such a model, a greater understanding of the interplay of the various factors influencing user behaviour was determined necessary. This led to the creation of a conceptual model of behaviour in context (outlined in section 2.7), which brought together and visualised a number of theoretical constructs for the first time in this field. The identification of goal framing theory as a useful lens to view behaviour has proved fruitful in this research and has subsequently been employed by other researchers in the field (Renström & Rahe 2013).

While the conceptual model constitutes a distinct element of theory building, it was evaluated and developed further through the analysis of the User Study. This in depth analysis of a large quantity of rich data led to the identification of a form of behaviour not well described in the existing literature. The concept of situational behaviour broadens existing definitions of habitual or routinized behaviour to include other forms of behaviour which exhibit externally driven reduced level of cognition on the part of the user. It allows for times when user attention is elsewhere, when they are busy, pressured, or otherwise distracted. These are factors which have a significant influence on the ability or willingness of a user to engage with reflective decision making and thus are extremely relevant to the field of DfSB.

The Behavioural Intervention Selection Axis (BISA) was created in response to the insight that there was a commonality between the sliding scale of behaviour from reflective to situational and the nature of the intervention strategies aligned along the DfSB axis of influence (Lilley 2009). This insight identifies that the key understanding behind choosing which type of intervention strategy to employ, must be based on the level of cognition that the user is willing or able to give to the task. The BISA is a novel theoretical construct, but it is one grounded in application and practice.

A related gap in the field of DfSB was also identified at the beginning of the research, and that was the lack of theoretically driven case studies which achieved a proven reduction in energy consumption. This research not only created new theory, but also successfully applied it in the form of the design and medium term evaluation of an intervention. This is one of the first medium term evaluations to generate quantitatively measured change in behaviour and resultant energy consumption reduction. This is a significant step forward for the field but also a significant validation of the theory developed in this thesis.

While the theories developed in this research are novel and appear promising in terms of application within the field, there is still a need for further exploration and validation of these and other areas within the field of DfSB. Further work by this and other researchers is yet needed for the field to develop into maturity.

10.5 Limitations of the Work

As with all research studies, there are clear limitations to the research presented within this thesis. This research is presented as a case study and as such all its findings are intrinsically bound to the constituent elements of the case. Foremost amongst these is the targeted selection of the participants undertaken by the LEEDR study at large. All the participants were located in and around Loughborough in the East Midlands of UK and all were families who owned their own home. Furthermore, given the fact that the participants volunteered to take part in a research study about energy consumption implies a level of predisposition towards energy saving attitudes. It cannot be said with certainty that the findings generated from this sample are indicative of the UK population at large or of populations coming from different cultures and countries. Additionally, it should be stressed that this research does not claim any statistical validity as the sample sizes used in all studies are far too small.

As this research acknowledges the constructivist role of the researcher in creating and shaping the research findings, this must also be considered a limitation. Though strenuous efforts have been made to maintain the credibility of the research, it remains to be seen if the generated theory would be as successful in achieving the goals of this research if applied by another.

As with any fixed term research project, the amount of time available has dictated the length and nature of the study. This thesis explores huge knowledge domains relating to human behaviour, design, sustainability and energy consumption, any one of which would be too large to explore exhaustively within the time bounds of this research. This is something which could be said of any research and this study has tried to use the allotted time frame to cover the most relevant areas as comprehensively as possible. Allowing for this, there are still a number of specific limitations, outlined below.

The time available for organising research activities with the participants limited the User Study to one session with each household. It would certainly have been preferable to have several sessions with each household, and also to undertake a range of different activities with them. However their time available to the project had to be shared with other disciplines (Social Sciences, Engineering) who had their own research agenda.

It was initially intended to develop and trial a suite of DfSB interventions, each targeting different behaviours. However the substantial time and resources required to do so was beyond the capacity of this study. The development and trial of the shower intervention, detailed in Chapters 6 and 7, took over a year of this researcher's time making further interventions unfeasible. In the same vein, the number of functional prototypes that could be produced was also limited by the time available. If it had been possible to produce a greater number and test the intervention in more households, greater credibility could be attached to the findings of the intervention study. The duration of the intervention trial was itself limited by two factors; the perceived willingness of the householders to take part in the intervention trial, but also the technical limitation of powering and maintaining an electrical device in the shower environment.

The validation of the BISA outlined in Chapter 8 clearly had limitations in terms of the scope and depth of the study undertaken. The first limitation was the fact that the participants were all design students rather than experienced design professionals. Furthermore, the BISA was only employed to develop initial concept ideas and not used to drive the development and testing of functional designs. This is a process which would take far longer and require access to a range of practising designers engaged in live design projects, factors which were beyond the scope of this research.

While the issues presented above show clear limitations to the research contained within this thesis, they also highlight a number of areas for further empirical research within this field.

10.6 Future Research

While it is felt that the research presented within this thesis has broken new ground in the field of DfSB, it is clear that further research is necessary to fully explore and validate the findings. This section outlines a number of research activities to be undertaken by the author with this goal in mind.

The Behavioural Intervention Selection Axis (BISA) developed in this thesis has proved successful in the context of this research study alone. It is crucial that the BISA proves useful and theoretically valid in the hands of other researchers and designers. To this end this researcher suggests three main activity strands for future development of the BISA.

Having thus far been developed and fully employed solely by this researcher, it is obvious that there is a clear need for the BISA and wider case study to be fully disseminated to the academic community at large for review. In this respect, publication of the major theoretical developments in international academic journals is considered a key next stage. It is perhaps only through the rigorous analysis and personal interpretation from the wider research community that the true theoretical value of this work can be judged. To this end, it is intended to publish the different strands of the research contained in this thesis in a number of peer reviewed academic journals over the coming year.

The design workshops run with the student designers as part of the validation of the BISA proved to be a fertile ground for theory testing and development. What was not developed though was any form of workshop toolkit which would help other educators recreate these workshops. Generating a repeatable format and set of educational artefacts is a further goal in the future. Such a kit would allow for the wider development and evaluation of the theories presented in this thesis and would also provide an accessible and easily implemented way of educating more student designers about the implications of the field of DfSB.

The author acknowledges that there is a still a need for more intervention development case studies, both in the wider field of DfSB but particularly with a focus to the further evaluation and development of the BISA. These interventions may well be developed by other researchers working in the field, but the author would also hope to further give this theory form through intervention.

The shower intervention developed in the course of this research displays much promise in terms of wider deployment. The key functionalities and persuasive mechanisms employed have been shown to generate a reduction in showering times. As outlined in section 9.5, the intervention could be easily reconfigured as a far more realistic proposition for further testing or even commercial development. Exploring the commercial opportunities arising from this design intervention is a potential further activity to be undertaken

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Appendices.

Appendix A: Daae's (2014) DfSB case study chart

Daae, J.L.Z, 2014, Informing Design for Sustainable Behaviour, Doctoral thesis, NTNU, 1503-8181; 2014:125

REFERENCE	PRODUCT	TARGET BEHAVIOUR	STUDY SET-UP	TARGET PROBLEM	PROPOSED DESIGN SOLUTIONS	TESTING SET-UP	RESULT
Rodriguez and Boks (2005)	Electrical appliances.	Turning off appliances/ standby.	10 participants; user diary, photos and interviews. Video recording of product usage. Shadowing 5 participants, recording time of product use.	70% do not notice appliances are on, 40% cannot bother switching off, 40% listened to TV without watching.	Product adjusts to user behaviour or use of other products, blind (mute) button, feedback about energy use.	-	-
(Lilley, 2007)	Cell phone.	Social sustainable phone use.	11 participants; user diary, 4 days. 5 participants; survey and interview. 258 participants; survey.	Problems with inappropriate topics or language, speaking too loud, loosing distinction between private & public and real & virtual, lack of awareness of surroundings, cameras intrude on privacy.	Phone advising use, phone display embarrassment, sound proof hands-free, real-time streaming.	-	-
(Edward Elias, 2011)	Refrigerator.	Opening/ closing of refrigerator doors.	Motion triggered camera for 9 and 18 days in 2 households.	Door opened most open when taking something out, loading, searching, using removed item, and doing something else.	Internal glass door.	Testing of prototype in one household: 10 days.	Measured: 43% reduction of user related losses, potential saving of 25-50 kWh/year.
(Jäger et al., 2009)	Refrigerator	Energy consumptio n.	6 families evaluated 3 concepts.	The concepts must be easy to use, provide direct feedback on the history of the usage and instruct towards behaviour change.	Timely triggers, emotional appeal and cooperation & social pressure. Leverage children is positive, when done carefully.	Measurements with sensors at 4 families of 2 days.	Humidity correlates with door opening, temperature with energy consumption.
(Tang Tang & Bhamra, 2012)	Refrigerator and freezer.	General usage.	18 families; survey, observation and 24h video recording, post-survey, interview.	Leave the door open while doing other things, forget to close the door, spoiled food in the back. Easier to change product than habits, lack of motivation to change, lack of information of impact.	Box for all breakfast items, a bottle drawer, hooks on door.	-	-
(J. Sauer, 2004)	Vacuum cleaner.	Adjust suction power.	-	People don't adjust the suction power on the vacuum cleaner.	Resetting the suction power, variation in instructions and on-product information.	36 participants used a vacuum cleaner.	Reset function and ecological instruction have an effect but information does not. Attitude and knowledge does not have an effect, but habits are important.
(J. Sauer, Wiese, & Rüttinger, 2002)	Vacuum cleaner	Adjust suction power.	-	People don't adjust the suction power on the vacuum cleaner.	On-product information, icon for optimal suction power and position of control.	40 participants vacuum cleaning a room.	Control on the handgrip result in more frequent adjustment than control on th body. The icons for optimal suction p had effect only with control on the handgrip whereas information only wh close to the control. Habits have a str effect.
(Wever et al., 2008)	Energy meter.	Usability problems.	Survey.	Problems with complex button combinations, difficult language and abbreviations, only possible to operate when plugged-in and difficult to perform basic tasks.	Focus on essential functions (energy cost), improved physical set up, LED feedback of consumption.	Lab testing of prototype.	Prototype 4 times quicker than old, less use of manual, better usability.
Broms et al., 2009)	Energy meter.	Raise awareness of energy consumptio n.	9 participants; interview and observation.	Visibility, place and complexity are crucial for integration into our behaviour.	A "clock" showing energy consumption for different hours during the day.	10 prototypes installed in homes for 3 months.	-
(Selvefors, Karlsson, & Rahe, 2013)	Energy meter	Use of online feedback system.	-	-	Eliq Online energy meter with web portal.	15 participants completed 12 months baseline measurements,6 months use of Eliq Online, 6 months follow up and 3	Significant correlation between frequency of use of the web portal and reduction in energy consumption. Households with high frequency reduced consumption by 9%. Also increase in motivation, perceived curtailment, investment

							most participants.
(S. S. Van Dam, Bakker, & van Hal, 2010)	Home energy managemen t system (HEMS)	Reduced energy consumptio n due to feedback.	-	-	The system consists of a sensor, a sending unit and a display, monitoring, registering and providing feedback about energy consumption.	304 participants used the HEMS for 4 months. 11 months later 189 responded to survey	Initially 7,8% reduction of energy consumption, but this was not sustained after 11 months. But there is great variation between participants and some are more receptive.
(Arroyo, Bonanni, & Selker, 2005)	The sink.	Saving usage.	-	People consume too much water.	Sink design with "just-in-time" feedback, positive reinforcements and social validation.	10 participants in one-time pilot and 15 participants in 2 months study, observations and bi weekly survey.	Users got quickly accustomed to the intervention and wanted more feedback.
(Kuijer & de Jong, 2009; Matsuhashi, Kuijer, & de Jong, 2009)	Bathing	Water consumptio n.	16 participants, diary study for 2 weeks, idea probing and group session. Follow up interviews 3 months later.	Bucket washing consumes 90% less than shower, and sink-shower combination 35% less. Shorter showers results in stress, No behaviour change after 3 months.	Sink-shower combination to simplify sink washing.	-	-
Matsuhashi et al., 2009)	Bathing	Water consumptio n.	3 participants from Japan, 3 from India and 3 from the Netherlands: Survey, cultural probe and interview. One and a half month duration.	Large variation in practice between cultures. Several combinations but only Dutch only shower, only Japanese only bade and only Indians only use bucket. The more running water, the more water is consumed.	-	-	-
(De Jong & Mazé, 2010)	Cooking	-	6 households: 1 Moroccan, 1 Iranian, 1 Surinamese, 1 Vietnamese and 2 Dutch. Observation, interview and survey; 10 weeks.	Large differences in how and where people shop and water consumption. Those who eat alone save left overs for later, which families throw away as there is not enough for everyone.	-	-	-
(L. McCalley & Midden, 2002)	Washing machine	Increase energy conservation behaviour.	-	People don't use the most energy efficient programs on the washing machine.	Feedback, with and without support of goal setting, self-set and experimenter set.	100 participants, 20 trials. Computer simulated washing machine.	Feedback alone has no effect, but supported with goals, it results in 21,9% and 19,5% reduction.
(Lidman, Renström, & Karlsson, 2011)	Washing machine	Dosage of detergent	15 participants; sensitising booklet, focus group, collage creation.	Detergent dosage is habitual, there is a need for feedback of dosing and cleanliness, guestimates of dosing, size of package affect dosing, desire for convenience,	4 prototypes. 1: Measurement cup with plastic frog, if too much detergent, frog drowns. 2: Chart to guide does according to laundry weight, scale and measuring cup. 3: Package where only right amount will pour out. 4: Detergent tablets.	16 households, 4 for each prototype; 1 month monitoring of dosing, 1 month compulsory use of prototype, 3 month voluntarily use. Finally, in depth interviews.	Prototype 1: High effect, also on long term. Fairly well accepted. Prototype 2: Very high effect, low long-term effect, high acceptance. Prototype 3: High effect, good long-term effect, well accepted. Prototype 4: Very high effect. Low long-term effect. High acceptance.
(L. T. McCalley, de Vries, & Midden, 2011)	Washing machine	Average amount of energy per wash	-	People use more energy than they need to by choosing "wrong" programs.	Four conditions: Goal setting, yes or no, and foot-in-the-door (first small then larger compliance), yes or no.	121 participants divided in the four groups. 10 test trials and 20 actual trials on computer simulated control panel.	Significant saving for goal setting alone. Foot-in-the-door inhibits response to the goal.
(Juergen Sauer, Wiese, & Rüttinger, 2003)	Water kettle	Energy and water consumptio n.	-	People boil more water than they need.	On-product information, task instructions and kettle design.	48 users used a kettle.	Information and instructions affected behaviour. Cup sized kettle reduced water consumption, but not transparent. Habits, beliefs and environmental concern affect results, but knowledge did not.

(Kuijer & de Jong, 2010; Kuijer & Jong, 2012)	Thermal comfort	Energy efficient ways to experience thermal comfort	Literature study, Japan; 4 interviews 2 observations, the Netherlands; 60 workbooks and interviews.	Personal heating more efficient than space heating and requires less planning, timing and skills, houses are often badly insulated, people dislike the air from heaters, balance ventilation and temperature.	Small cherry pit filled pillow heated in the microwave oven, to provide personal heating.	60 users used product for 2 days; Video interview.	Hygiene issues with microwave oven, limited heat properties of product, product hard to bring around, changes must happen together with building design and climatic systems. Potential for attractive body insulation.
(I. N. Pettersen, 2013)	Thermal comfort	Residential heating.	Interview with 5 representatives at producer and 3 at energy providers and public organization.	Efficiency vs sufficiency, focus on thermal comfort, resistance against retrofitting,	Tailored advice to what to buy and how to interact, reduce need for active heating, renewable energy, temperature zones, adapt heating to activities, better mental models.	-	-
(Wilson, 2013)	Thermal comfort	Open window while heating is on.	Interview and guided tour of 7 households	Thermal comfort varies greatly and is based on freshness, light, physicality and sound. Heating is essential, affected by social expectations, often routines, lack of feedback and knowledge.	Prototype providing feedback of the status of the heating system in tandem with the status of their window.	2 focus groups with prototype and user trials with prototype installed in 2 households for 4 months with pre and post interviews.	Feedback improved understanding of consequences and how the system works but limited behaviour change. Receptiveness to information decreased towards the end of the trial. Use of ambience well received.
(Renström, 2013)	Thermal comfort	Use of central heating system.	Two studies: Diary study and survey with 35 participants. Annotation activity, generative exercise, interview and survey with 30 households.	Heating systems are difficult to understand and use, inadequate feedback, uncertain how much control they have, use of additional heating or cooling artefacts, poor understanding of amount of energy heating or hot water consume.	-	-	-
(I. N. Pettersen, 2013)	Dishwashing	Use of dishwasher.	Interview with 5 representatives at producer and 2 others	Reduce pre-rinsing, make pre-rinsing less wasteful, run full machines, choose right program.	Skill transfer at sales point, improved eco-labels, separate reusable and dirty items, flexible interior, optimal default, better mental models.	-	-
(I. N. Pettersen, 2013)	Audio-visual media usage	Interaction with televisions.	9 interviews with representatives at producer and 2 others.	Intensity of use (what equipment at the same time), under what contextual conditions, the applied settings, duration of use, choice of product and lifetime of product.	Information of product properties at point of sale, improved eco-labels, improve display technology, improve experience of smaller screen, alternative business models, different viewing modes, avoid stand by mode, shift to alternative activities.	-	-
(Hielscher, Fisher, & Cooper, 2008)	Hair care.	Hair cleanliness.	In depth interviews with 24 women and 12 hair-care experts.	Perception of cleanliness is culturally dependent, and may be described on a scale from too dirty to too clean.	-	-	-
(Dillahunt, Becker, & Mankoff, 2008)	Motivating environment al behaviour.	Attachment to virtual polar bear.	-	-	Animation of polar beer. The more environmental actions participants do, the more ice. No action – less ice.	10 participants; one week. 10 participants in control group. Initial survey.	Significantly more fulfilled commitments, higher environmental concern and greater care than control group. Not more commitments.
(Daae and Boks, 2014)	Wood stove	Burning firewood in a sustainable way	18 ethnographic studies with wood stove users	People reduce air vaults in the wrong order, reduce air too fast, don't close the door, close air completely, light the fire from the bottom, burn unsuitable material.	Prototype with combined air lever closing primary air on first part of movement and indication for position of ignition, fast burning and slow burning, thermometer with indication when air should be adjusted and simplified user manual.	10 participants lighting fire in the prototype and 10 participants in a regular oven, in a lab. Maintaining fire until 80% of wood mass is burned.	Only half of the participants using the prototype paid attention to the design and were affected. Those burned more correctly, gained less soot on the glass door, emitted less fine particles and CO2, but not significantly.

Appendix B: GTKY Information Booklet

Contact us

If you have any queestions or concerns about the project, your first point of contact is:

Dr Lynda Webb
Building Energy Research Group,
Dept Civil and Building Engineering,
Loughborough University,
LE11 3TU

Tel: 01509 228745,

Email: L.H.Webb@lboro.ac.uk

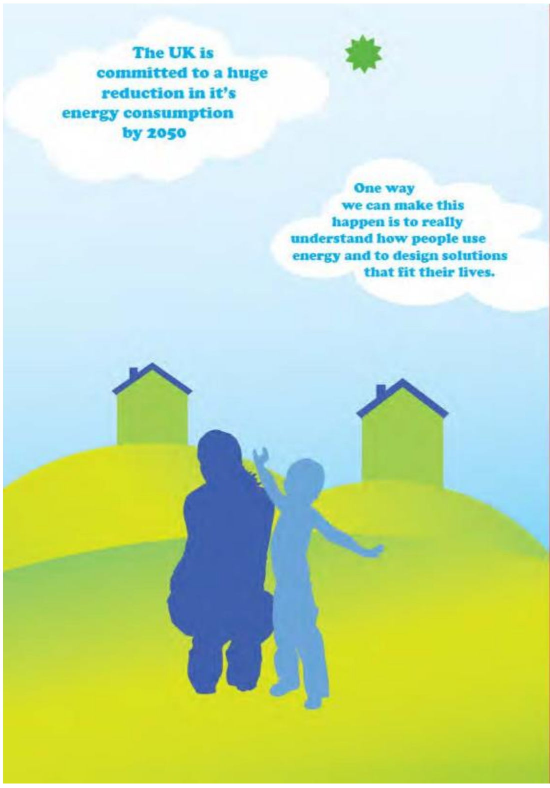
LEEDR is supported by:

Loughborough University · e.on · O2 · AlertMe

leedr
Low Effort Energy Demand Reduction

What's it all about?

Participant Information Booklet



Are you up for it? What next?

Once all your questions have been answered and our team has made sure that our technical requirements for the project are compatible with your house, we will ask everyone in the household (including children) for their consent to participate in the project. We will then arrange a suitable time to carry out the first activity.

Welcome to the project!

Safeguards

LEEDR puts the well-being of you and your family first. All activities will be explained in detail, and you can always decide if and to what extent to take part.

Participation is voluntary, and you may withdraw from the project at any time. Unless you tell us otherwise, your participation is anonymous. All information and recordings will be stored securely. You decide on the extent to which we can use them.

Further information has been included as a separate insert in your information pack.

The purpose of LEEDR project

The LEEDR project seeks to better understand how and why families use energy and digital media (mobile phones, computers, TVs, etc.) in the home, and to explore energy-saving opportunities and technologies in a way that addresses real people's needs, values, and routines.

Our unique approach involves a variety of activities over the course of three years. As well as monitoring the energy used by your appliances, space heating and hot water, we will actively engage with family members to learn about the things that are important to you within the context of your homes and lives.

What's in it for you?

People often find the experience of taking part in an academic research project engaging, enriching and fun.

During the study, we will be able to tell you how you are using energy in your home and whether there might be easy ways of reducing this. You may also learn more about yourself, your home and your family along the way.

Who we are

The LEEDR project is funded by the Research Councils UK and brings together a team of researchers from a range of subjects. We are engineers, computer scientists, designers and social anthropologists, all based at Loughborough University.

By combining our skills and interests, we produce research which will be relevant to a wide range of people, including other researchers, energy companies, government and, importantly, the general public.

Meet the team at
http://www.leedr-project.co.uk/team.shtml

Interested... what's involved?

As LEEDR is a three year study, we want to make the project an enjoyable experience for your whole family. We will work closely with you to ensure that home visits are arranged at your convenience and busy research periods are followed by plenty of breathing space for everyone involved.

The first stage of the LEEDR study involves four core activities which are detailed in the following pages. The rest of the project will follow a similar format as we explore with you your energy use.

Monitoring equipment installation

During this activity we will set up energy monitoring equipment in your home. This will be carried out by members of the team and professional engineers. The information collected over the three years will be sent back to Loughborough University and stored securely. The equipment will consume less than £5 of electricity each year, and we will, of course, be delighted to cover the cost of this.

Further information has been included as a separate insert in your information pack.

2-6 hrs

Guide to the activities

Each of the following pages has icons representing what is involved in each activity. These show what we will be doing, how much time we need, and how many members of the family can be involved.

whole family

taking photos

note taking

one householder

video recording

techincal

time required

audio recording

keeping in touch

Home video tour

This is where we get to know your home – what it looks like, how it feels to you, how your family make use of its spaces. You are the guide as we follow you around the house and explore each room with you. As we walk around, we might ask you about your daily routines – how you heat each space, where you dry your laundry, when and where you watch TV.

Further information has been included as a separate insert in your information pack

1-2 hrs

Getting to know you

We would like to come over and give your family a night off cooking!

We'll bring over a take-away meal and talk to the whole family about your everyday lives. We've also got some fun and easy interactive tasks that will tell us (and often you!) about your routines, aspirations, and the way you use energy and digital media.

Further information has been included as a separate insert in your information pack

2hrs

Appendix C: Intervention Trail Info Booklet

Contact Us

If the device has stopped working normally or if you have any queries or concerns, please do not hesitate to contact the people below:

Marcus Hanratty
Sustainable Design Group, Loughborough Design School, Loughborough University, LE11 3TU
Tel: 075 6187 433 Email: m.hanratty@lboro.ac.uk

Dr Lynda Webb
Building Energy Research Group, Dept Civil and Building Engineering, Loughborough University, LE11 3TU
Tel: 01509 228745, Email: L.H.Webb@lboro.ac.uk

LEEDR is supportted by:

Loughborough University

enuf

Shower Trial

participant information booklet

leedr

Showering is probably not something you think about that often, but did you know….

The average person in the UK uses 150 litres of water a day, compared to 20 litres a day for someone in the developing world.

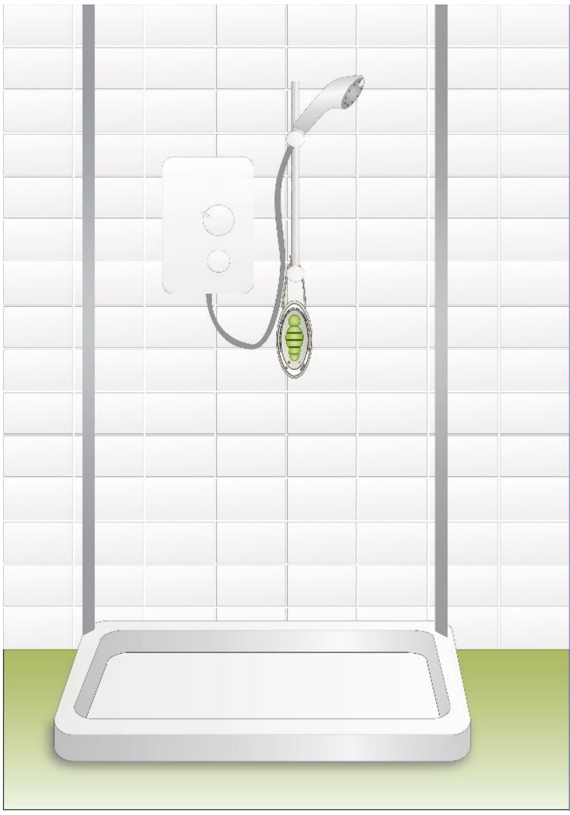
A recent study by Unilever study showed showering could be costing the average UK family over £400 a year*

An 8 minute shower uses around 60 litres worth of hot water.

Newer combi-boilers and electric showers mean we can stay in the shower for longer and longer. This means some families are literally pouring hundreds of litres of hot water down the drain every day.

If a person were to try and generate enough electricity to heat the water for an 8 minute shower on a bicycle powered generator it would take them over 7 hours** of hard peddling!

* http://www.unilever.co.uk/media-centre/pressreleases/2011/sustainableshowerstudy.aspx
**(60l heated 20˚C degress = 5mj = 7.5hrs at 200w output)



What is this device?

enuf is a new device that tries to help you reduce the amount of hot water your family uses in the shower. It uses a range of feedback methods to allow you to keep track of how long you have been in the shower, and encourages you to be more efficient. **enuf** is a safe battery powered device that installs quickly and simply on to your shower without any plumbing or wiring.

It doesn't tell you what to do, or force you to change your routine, it just wants you to question **"how much is enuf?"**.

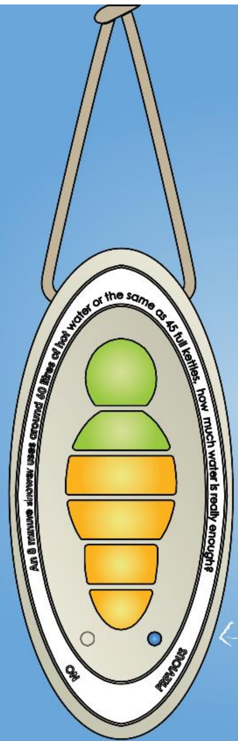
enuf

How does it work?

What does enuf do, and how might it help you reduce waste and save water and money?

Well it has a few tricks up its sleeve…

1. Water's Hot!
Instead of turning on the shower and waiting for a few minutes to make sure the water is hot before getting in, enuf lets you know exactly when the water is ready. It uses a specially adapted shower head to monitor the flow temperature, and when it senses the temperature is right it chimes to let you know. No more hot water needlessly going down the drain!

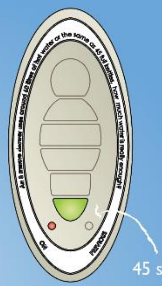


2. Previous User
Saving water and energy in the home requires everyone to pull together, so as soon as it switches on enuf shows you the previous persons shower total on the LED display. This is indicated by the blue Previous User light on the bottom right. Is everybody doing their bit to save money and water? Should you be trying to beat the record? enuf will try and tell you.

How does it work?

3. The Countdown

enuf uses a simple coloured led display to let you know how long you've been in a hot shower. The sections of the display start counting up from the bottom and have three main phases. First up, the green phase; this is what you want to be aiming for!



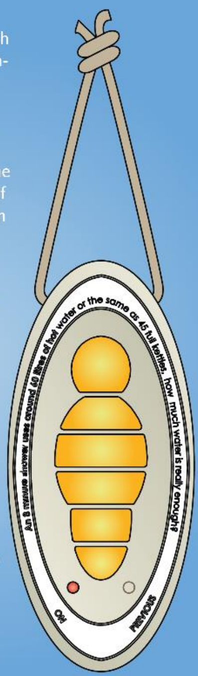
It last for up to 4.5 minutes and you'll hear 4 chimes when it's over. This is the optimum period of time for most people to wash without wasting lots of unnecessary water.

It might seem short at first, but you can challenge yourself to make your routine more efficient and be finished before it's over. Many people actually already shower in this time so it might not even be a challenge for you!

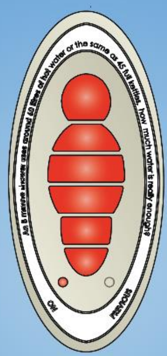
Next up is the amber phase which runs from 4.5 minutes until 7 minutes, if you're finishing in here you're doing OK but you're still using a lot of hot water to wash.

See if you can change your routine to finish a little bit more quickly. If you tend to drift off or day dream allow yourself to do it after the water is off!

Enuf will give 7 chimes when this phase is over.



How does it work?



Anything over 7 mins is in the red zone. 8 mins commonly equal around 60 litres of hot water down the spout for so if you stay in for 14 mins it could be over 100 litres! Think about how often you shower and what that adds up to per week or per year; it's a lot of money and a lot of CO_2.

How much is really enuf?

What is the trial?

If you are all happy to try out this device in your home and sign the consent forms attached we can begin the trial! The process is divided into 4 main parts which are explained below.

1. Installation

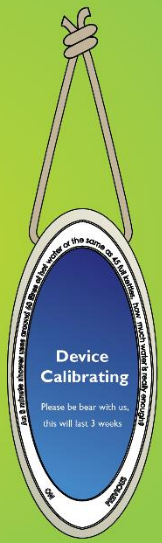
A member of the LEEDR team will come around and install the enuf device in your shower at a time that suits you. The installation will take 30-60 mins and doesn't involve any alterations to your plumbing or electrics. The only change we'll make is to replace your shower head with a new one for the duration of the trial, and after the trial is over we'll leave your bathroom exactly as we found it.

enuf is waterproof and battery powered (just like a shower radio) which makes it completely safe for use in wet environments. As the trial goes on, a member of the LEEDR team will need to come around and change the batteries every 3 weeks. This will take around 30 mins, but again we'll come at a time that suits you and minimise the amount of your time we take up.

What is the trial?

2. Learning Phase

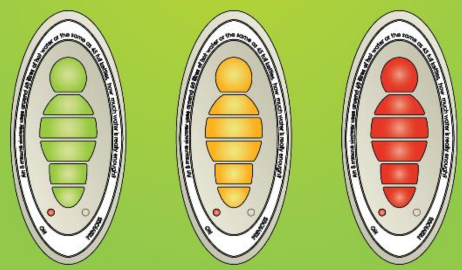
For the first 3 weeks the enuf device will 'calibrate' or learn about the duration of your current showers. Finding out how much time you normally spend in the shower allows it to see if there are any changes during the active phase. During its learning phase enuf will be silent and discreet - you'll probably forget it's even there!



What is the trial?

3. Active Phase

This is when enuf comes to life! By letting you know how long you've been in the shower and encouraging you towards the most efficient times, enuf allows you keep track of the length of your showers and try to reduce wasting hot water. It does this in the different ways which we explained in the "How does it work?" section. This period will last at least 3 weeks and possibly longer if you're up for it.



What is the trial?

4. Feedback Session

Because enuf is a new design idea we would really want to find out what you thought about having it in your home for the trial. So before we finally take the device away we'd like to talk to you to get a sense of what it was like living with the device and to hear any sugges-tions or concerns you might have which could improve the design. This interview session is designed to last about an hour and can be arranged for a time the best suits you.

Overall, we hope that you will find the trail to be an interesting and engaging experience and we'd love to have you all on board. If you're unsure about anything at all, please ask us and we will do our best to help.

device information cards

Appendix D: GTKY Interview pack and maps

Getting to Know You

-Pilot Interview-

Loughborough University

Loughborough Design School

Carolina Escobar-Tello, Marcus Hanratty, Tracy Bhamra, Val Mitchell

leedr

Low Effort Energy Demand Reduction

Beta01

Getting to know you

Setting: Just ***BEFORE*** *having dinner with the participant*

1. Briefly, go through the project (purpose) with the householders
- Ask for permission to use voice recorder and photographic camera.
- Clear any doubts

2. Explain what this 1st Interview is about – getting to know you. This will cover learning about the:
    - Background of the family members
    - Background/history of the house
    - Energy and Sustainability knowledge and awareness
    - Occupancy
    - Aspirations and Future gazing
    - Clear any doubts

NOTES

Loughborough University, April 2011 leedr

Getting to know you _ Family Background

Learning about your lifestyle

Setting: While having dinner with the participant family

Family Background

1. What sort of household/family are you? (busy, sporty, ...)
2. And individually? (briefly, what sort of person are you – interests, work. How would you describe yourself (happy, busy, laidback, lazy etc etc)

House Background

5. Would you mind telling us a little bit about the history of the house? (i.e. changes: extensions, DIY work)
6. What makes it home? *(Talking through the 1/2 pictures the householders prepared for the interview)*
7. Do you like living here? (favourite places, things)
8. Do you feel anxious about any parts of it?
9. Would you do to change your home if you could?

NOTES

Getting to know you _ Energy and Sustainability

Learning about your family's energy use and understanding of sustainability

*Setting: **AFTER** having dinner with the participant family*

Energy

1. Why did you volunteer to take part of this study?
2. How would you define energy? What does it mean to you?
3. Would you consider yourself energy savvy?
4. What energy sources or types do you use in the home? (prompt: electricity, gas, renewable)
5. Which processes do you think use the most energy in your home? (prompt: laundry, tv/radio/music, lighting, baths/showers, heating)
6. How do you know energy is being used in the home? (prompt: seen, heard, felt)
7. How do you know if too much energy is being used?
8. Have you thought about, or done any recent changes to your lifestyle to reduce the energy consumption at home?
9. Who uses the energy in the home?
10. And who switches the heating on and who switches it off?

Perceptions of others (morals, ethical values and behaviours)

11. Do you know any households or families who you think wastes energy? (examples of how they think other people waste energy)
12. Do you know any households or families who you think use energy really sensibly? (ask for examples of this again).

NOTES

Getting to know you _ Energy and Sustainability

Learning about your family's Energy use and understanding of Sustainability

*Setting: **AFTER** having dinner with the participant family*

Sustainability

1. Are you familiar with climate change and global warming?
2. How about Sustainability? The environment?
3. Do you believe that your behaviour and everyday lifestyle contribute to the above?
4. How willing (and easy) do you think it would be to make changes in your family lifestyle in order to become more environmentally friendly?

To wrap up this section:

1. Finally, do you know how much energy do you use?
2. And the cost?

NOTES

Getting to know you _ Occupancy

Learning about how you spend your time at home

Setting: Interactive task with the participant family (householders to populate home diagram while answering questions from this section)

Interactive Task

1. What would be a normal working day… who wakes up first? (populate 1st map)
2. And then what happens at midday? (populate 2nd map)
3. And in the evening? Who gets back home first? Who goes to bed last? (populate 3rd map)
4. How about a weekend day? *Repeat questions 1-3*
5. Does anyone work from home? How often - what days/time of the day?

NOTES

Getting to know you _ Occupancy

Learning about how you spend your time at home

Setting: Interactive task with the participant family (householders to populate home diagram while answering questions from this section)

Interactive Task – Week Schedule: Morning (Start – 12) - Winter

	Mum	Dad	Son
4.00am			
5.00am			
6.00am			
7.00am			
8.00am			
9.00am			
10.00am			
11.00am			
12.00m			

Getting to know you _ Occupancy

Learning about how you spend your time at home

Setting: Interactive task with the participant family (householders to populate home diagram while answering questions from this section)

Interactive Task – Week Schedule: Midday (12.00-6.00pm) - Winter

	Mum	Dad	Son
12.00m			
1.00pm			
2.00pm			
3.00pm			
4.00pm			
5.00pm			
6.00pm			

Getting to know you _ Occupancy

Learning about how you spend your time at home

Setting: Interactive task with the participant family (householders to populate home diagram while answering questions from this section)

Interactive Task – Week Schedule: Evening (6pm – Close) - Winter

	Mum	Dad	Son
6.00pm			
7.00pm			
8.00pm			
9.00pm			
10.00pm			
11.00pm			
12.00pm			
1.00am			
2.00am			
3.00am			

Getting to know you _ Occupancy

Learning about how you spend your time at home

Setting: Interactive task with the participant family (householders to populate home diagram while answering questions from this section)

Interactive Task – Weekend Schedule: Morning (Start – 12) - Winter

	Mum	Dad	Son
4.00am			
5.00am			
6.00am			
7.00am			
8.00am			
9.00am			
10.00am			
11.00am			
12.00m			

Getting to know you _ Occupancy

Learning about how you spend your time at home

Setting: Interactive task with the participant family (householders to populate home diagram while answering questions from this section)

Interactive Task – Weekend Schedule: Midday (12.00-6.00pm) - Winter

	Mum	Dad	Son
12.00m			
1.00pm			
2.00pm			
3.00pm			
4.00pm			
5.00pm			
6.00pm			

Getting to know you _ Occupancy

Learning about how you spend your time at home

Setting: Interactive task with the participant family (householders to populate home diagram while answering questions from this section)

Interactive Task – Weekend Schedule: Evening (6pm – Close) - Winter

	Mum	Dad	Son
6.00pm			
7.00pm			
8.00pm			
9.00pm			
10.00pm			
11.00pm			
12.00pm			
1.00am			
2.00am			
3.00am			

Getting to know you _ Occupancy

Learning about how you spend your time at home

Setting: Interactive task with the participant family (householders to populate home diagram while answering questions from this section)

Questions after task

6 . Would you mind telling us what would be the main change in your home routines during Summer?
7. Do you spend time as a family? What do you usually do during this time? (when, days, hours)
8. Is there a time when anyone spends time alone at home? What do you usually do during this time? (when, days, hours)
9. Are you ever away for work? What happens at home in those occasions?
10. How about holidays? (when, frequency) What happens at home in those occasions?
11. And visiting family or friends? (when, frequency) What happens at home in those occasions?
12. Would you have guests staying over? (when, frequency) What happens at home in those occasions?
13. Illness? What happens at home in those occasions?
14. What are the main means of transport you use as a family? (frequency, duration)

NOTES

Appendix E: Intervention Interview Guide

LEEDR – Shower Device Feedback Session MHanratty

Ask all family members.

Background and Information

1. Prior to the trial, had you ever considered how much showering would have cost you?

2. Did you have any idea of how much water was used by a shower? If so how much did you think it used?

3. Were you surprised when you saw the information provided? Did it make you think differently about water and energy use?

4. Did it motivate you to try and use less water or energy?

5. Do you have a regular shower routine? Can you describe it? For example, you shower at the same time of day every day? What affects this, for example, how often you wash your hair etc.?

6. What were your feelings about showering before the device arrived? Did it mean more to you than just washing, eg. Something you'd look forward to, relaxing, enjoyable , therapeutic. Were these feelings changed by the arrival of the device?

Use

7. What did you think of the appearance of the device, did it look like a real product?

8. Did the unit function how you thought it would from the information provided?

9. What did you think of the **"water is hot"** alert, did it effect what you did?

10. Would you have known how long you spent in the shower before the device came along? What was your reaction the first time you got feedback

11. Did you feel that the time periods indicated by the colour lights were reasonable? If not why not?

12. Do you think that the sounds changed the length of your showers? If so in what way? If so which sounds in particular?

13. Do you think that the lights changed the length of your showers? If so in what way? If so which lights in particular?

14. Did you try and finish at a particular point or colour when you were showering, If so, which point and why did you settle on that?

15. Did anyone manage to finish in the green section? What did you think of the fanfare sound? Was it just your normal time or did you make an effort to be quick?

16. Did the device make anyone feel guilty for staying in too long?

17. Did you ever go through all the RED lights? If so how did that make you feel? Did it impact on your behaviour?

18. What was your reaction to the end of shower sounds? How did they make you feel? (e.g. the fanfare, or sad trombone make you feel)

19. Did that change over the trial?

20. How did you change your shower routine because of the device? Did any of you try to work around the device .eg. do some things without the water running. Or did anyone have a double shower and get 2 big fanfares instead!

21. Aside from just washing yourself, would ever do any of the following in the shower, shaving, brushing teeth, shampoo + conditioner, daydreaming, soaking. Were these activities impacted upon by the device? How acceptable was this? did you adapt your behaviour and if so how?

22. If the device led to a change in routine, did the new routine become normal after a while? e.g. you began to finish in a shorter time without really having to think about it?

23. Were you interested in how other members of the family were using the device? Could you hear them?

24. Did you ever talk about what was happening with each other?

25. Did the device work for all of your showers? Were there many times when it didn't turn on?

26. Was a noticeable lag before it would realise you had finished? If so how long? Did you find this to be a nuisance?

27. How accurate do you think the feedback was?

28. What didn't you like about the device?

Future

29. If it turned out that you could save £100, X liters of water and X kg CO2 by using the device, would you consider having one in the future ?If it was more accurate and built in to a shower for example.

30. If you could change some things about its design, what do you think would work better or be easier to live with.

31. Are you looking forward to it being gone? ?If so what are you looking forward to? (To having long showers? Do you think you'll go back to your old routine? Or will you miss getting applause in the morning?!?)

Show print out of data, go through it and re-ask question 29

Appendix F: GTKY Thematic Analysis

GTKY Thematic Analysis

1 Contents

Introduction

This analysis of the Getting to Know You (GTKY) interviews takes a broad ranging and holistic view of energy consumption as a product of behaviour. It does not focus explicitly on the composition of the sample or on specific quantitative findings but rather on the interfacing elements of energy consuming behaviour as uncovered through thematic analysis of the 20 family interviews. Individual behaviours are defined as actions or sequences of actions intended to achieve a specific goal, i.e. choosing a setting on the washing machine. In places the analysis refers to practices, these are defined as a group of linked behaviours i.e. laundry as a whole. This definition of practices differs from that of Practice Theory and should not be interpreted as such.

With the exception of digital media practices, this analysis does not focus on individual practices as separate sections. This is reflective of the nature of the interviews which were not directed as an exhaustive investigation of other practices, but were concerned with uncovering the role of energy consumption in the participants' lives. These other practices will be analysed at a later stage through a more targeted investigation.

While this analysis primarily seeks to draw out commonalties of energy consuming behaviour across the participating households, it also seeks specific design insight. Theses insights and opportunities are shown in bordered BLUE TEXT and reference a range of Design for Sustainable Behaviour related topics and mechanisms.

2 Digital Media: Role and Impact

2.1 Introduction

Digital media use has many interesting aspects that can be difficult to classify, as such this analysis will be predominately centred around the various primary hardware platforms such as TVs, portable devices, etc. From this departure, the many more contingent or amorphous features of DM use which are less tangible will be, wherever possible, connected to the relevant hardware or channels.

2.2 Gaming

Gaming is highly prevalent in almost every family, and is an almost universally popular form of playing for children. There seemed to be a progression of gaming forms with younger children often having Nintendo DS's and Game Boys, moving on to Wiis for the whole family, and with teenagers often moving on to PC or Xbox/Play station type games. Furthermore, gaming was a focal activity of more dispersed occupancy particularly with males, with many of the sample going into other rooms, often upstairs and playing computer games. Whether this dispersion is driven by gaming, or if gaming is more incidental to people seeking a more personal space is unclear. In a number of cases, parents were quiet happy for children to entertain themselves playing video games as it kept them occupied and quiet.

2.2.1 Social Gaming

For many families computer gaming , especially the Wii, is a way spending time together, and is often associated with holidays and parties as a fun group activity.

H05MA: We've actually only got the Wii at the moment.

I: Would that be a family thing or just that you have friends over or..? [Discussion]

H05FA: I do, yeah. We have daft things on it, don't we?

H05MA: Half a bottle of wine and you're…

H05FA: Yeah, we do play on it in the winter. It tends to be the winter, doesn't it?

H05MA Yeah.

I: And what sort of games do you play on the Wii?

H33mc1: We normally play games with lots of sports stuff.

I: Ah, so moving and dancing?
H33FA: Oh, we do have [xxxx] but we don't play it very often, do we, because we get a bit competitive. [chuckling].

H33mc1: Like Jocelyn starts to say "Who won?" and then she's like… She says she's on somebody's team and then they lose and then she says she's on someone else's team. [laughter].

This would often be more regular amongst siblings, where it could be a daily occurrence in some cases. Amongst adult participants, in general MAs were more likely to play computer games than FAs, both on their own or with other family members.

I: And is the Wii something that you do together as a family or would it be Louise and Daniel who mainly do that?

H28FA: It's mainly Daniel and you, isn't it?

H28MA: Yeah. Mainly, yeah.

H28mc: Actually I don't use it very much anymore.

H28fc: No, you haven't for a while.

H28MA: You haven't for a while, but before you came I just had a go at the Tiger Woods PGA Tour in America before you came, so…

While is sometimes gaming social within the household, in some instances participants socialised with their friends remotely, using X-box live, with one 12 year old boy (H45mc) claiming to spend an hour before school and 2-3 hours after school every day playing "shooting" games with his school friends online while chatting over wireless headsets. In this instance, both parents felt that this was the normal way for him and his peers to socialise, even hinting that while they didn't really understand it they felt they would be putting him at a disadvantage socially to deprive him of it.

> **H43MA**: The most communication he might do is when he's playing live with somebody.
>
> **H43FA:** On Xbox live he'll talk to his friend who's on Xbox live.
>
> **H43fc1:** Yeah because he can connect with these headphones and microphone and talk to his friends.
>
> **I:** So you can play together on the Xbox live.
>
> **H43FA:** Yeah and they've got headsets so they can talk to each other as well.
>
> **H43MA:** We've all got a live account. Well these have, you haven't because you don't play.

This is a good example of the context shift attained by some forms of DM, instead of perhaps playing outside in the green with other children from the neighbourhood; this boy was playing and talking with friends who lived on different side of the town.

Amongst younger participants in particular, video games are highly embedded in their lives, and often listed as the biggest form of recreation. Their social aspect ranges from the bringing together of family members around a console, to on-line connected social experiences, to its normative role as a dominant social activity amongst peers.

2.2.2 Dispersed Gaming Suites

There is another facet to video gaming and that is the secondary function provided by some console types (i.e. Wii, X-Box) as internet browsers and media players. This may mean that the devices and related peripheries are in use as music systems, radios, and even for internet TV where old non digital screens have been delegated to the gaming suite. The energy consuming profile of these other activities may be at odds with the theoretical minimum needed for the activity (i.e. an ipod and speaker dock may use much less energy to play music than a Wii and TV set), this is unverified in this case however.

H09mc2: Doesn't the Wii TV, the Wii screen count as a TV?

H09MA: Working TVs… You know the signal's just been turned off, the television signal? You know we've gone to digital?

I: Yes.

H09MA: The children had some old televisions in their bedroom which are obviously analogue TVs, so they don't actually work with the at the moment. So we're considering whether we should get rid of them and get a digital.

In terms of energy use there are several concerns emerging: One is the obvious energy the consoles and displays use, often they are incorporated into DM suites of TV, DVD, Sky Box, Console(s). All of which may be kept on standby (see section on TV) for a number of reasons. There was suggestion of some consoles being left on and paused for extended periods to keep game position for their return. Certainly there were reports of regular, often daily, long periods of play.

Furthermore, in many cases video games were played away from the rest of the family in a bedroom, this would generally necessitate heating and lighting as well as other incidental energy use. This is compounded by the sedentary nature of most gaming activities (with the exception of the Wii) which would presumably require more heat in the room. However, scope for curtailment of this pastime is unsure given its entrenchment and personal and social importance.

The prevalence of gaming, especially amongst the younger members of the households offers some interesting opportunities for design.

- ***It is an existing channel of long term engagement with persuasive DM.***
- ***It can be a shared activity for the family, providing an informational focal point to the group.***
- ***As a shared activity, it can bring the family members together into the same room, with the opportunity to reduce energy load elsewhere.***
- ***Game mechanics are an established route to behaviour modification, and could perhaps be mirrored in design interventions.***
- ***It positions younger members as independent and active, perhaps offering a channel to creating energy champions driving off screen actions***

2.3 Television

By and large, Television is the most commonly experienced DM activity in the participants' homes. It is used in a myriad of forms, times and places, with new media like smart phones, tablets, and laptops all adding to the flexibility of the experience. It is the dominant recreational activity with all householders watching it most days. Its roles are many, including entertainment, relaxing in the evening, for the provision of news and weather at regular times, as parenting tool to quieten children, as background noise, and many others.

TV watching was strongly tied into existing routines, with regular patterns of watching (i.e. over breakfast, after school, evenings) emerging as a daily norm in many cases. Often it is watched as an adjunct to other behaviours like eating or cooking a meal, but it is also very much an activity in in its own right. The division between these states is not clear cut, and it is quite possible that "switching on the TV with a cup of tea" is a fully compound behaviour equally dependant on both aspects.

There is another element of regularity driven by the TV schedule itself, programmes like Strictly come Dancing, soap operas, and children's cartoons all had their regular fans and adherents and were often key points cited by participants when recounting their routines. In this sense they become regular "time stamped" moments around which the day can be organised, and to a certain extent occupant behaviour can be planned for.

I: Do you ever sit down to watch a TV programme together?

H33FA: Yeah, Strictly on a Saturday night. That's a must, isn't it? [laughter].

I: And in terms of more traditional things like TVs and radios and that, would you be big users do you think?

H41FA: I'm big TV. Coronation Street

This obviously has potential in terms of directly forecasting energy use (e.g. half time in the FA cup is a well-documented electricity demand peak time as millions of kettles are flicked on), but may also prove useful in terms of targeting energy use reduction in other areas of the home as it places people in a specific location regularly.

TV emerged from the interviews as the main social activity within the household, with it very common for whole family units to gather in the lounge around the TV most evenings, in some cases for the evening meal itself. This was particularly common in families with pre-teen children who might be more likely to take their lead from the parents or would not have their own TVs in their bedrooms. Interestingly, this behaviour was often at odds with families self-described interests but only emerged as a regular feature when the routines were mapped in the interactive task (often families focused on less frequent but more perhaps more aspirational activities like "going to the park", or "entertaining friends").

The centrality of these shared moments around the TV are reflected by fact that the main TV room and the couch opposite it were often chosen as "what makes this house home" by participants when questioned.

I:. The next question is "What makes it home?" and you've sent us a picture.

H38FA: Yeah, lots of people in it. That makes it home.

I: And I take it this sofa is here in the lounge?

H38FA: Yeah.

H38MA: Yeah. So we sort of sat there and had the camera turned to us.

H38FA: And we spend a lot of time in this room. We play in here and we dance in here and we watch telly in here and we read in here and it's warm and it's cosy.

Indeed these moments of relaxing together around the TV could be very casual and unintended, but often they were a conscious way of spending time together as a family. This becomes particularly prevalent at the weekend when many of the participants reported sitting around together to watch a film or a particular program.

I: Are you a film watching family or is it just individuals?

H28MA: We are, yeah.

H28MA: Yeah, we watch quite a few.

Interesting elements of these social moments are the comfort making practices that can evolve to enhance them. Some participants reported using blankets and hot water bottles and snuggling up together on the couch together. This form of personal heat making is obviously much lower energy impact, but also enhances the goals of the sedentary activity; comfort and relaxation.

H33FA: Yeah. If I'm at home, especially in the winter, and I'm not doing anything in the house, then I get cold quite quickly. But we've got a blanket that I can kind of put on me if I'm sitting down, which I don't do a lot of. There's a blanket behind the sofa and we all often get under that blanket, don't we, if it's cold and we're watching something on the telly.

However not all TV watching was a social activity which brought people together. In some instances TV causes people to disperse through the house, when there were schedule conflicts with different people wanting to watch different programs at the same time. This is obviously facilitated by most houses in the sample having more than one TV, with TVs commonly found in kitchens, lounges, bedrooms, offices, and play rooms.

> H09mc2:: Only when I wanted to watch X Factor till 10 o'clock.
>
> H09FA: Yeah, but now you just go in our room or something, wont' you, so I think we'll just get rid of them, so don't count them.

As discussed previously, there is an element of older children seeking independence by watching TV in their own rooms. There were even reports of people watching the same programs in different rooms.

Can we encourage social TV watching in order to consolidate people into one room? How can we translate that into reduced energy use in the rest of the home? How strong are the forces that cause people to disperse around the home to use other DM and what interventions or devices could diminish them (i.e. iPad and head phones).

Another instrumental role of TV was its use by parents as a calming tool or for keeping children engaged while they had to perform other tasks. In one case the TV was used as a distraction for three very energetic children for both dressing and undressing, and some meals every day. In other cases it was often switched on after school to give the kids a break after school while a parent was making supper.

It was often found that old TV sets were handed down to children when a new digital ready one was purchased, some of which can now only be used for DVDs or as monitors for video games. These are often in the children's bed rooms, where the lack of antenna acts as a parental safe guard in terms of content. However the energy efficiency of these sets is unknown and may be of substance.

> H09MA The children had some old televisions in their bedroom which are obviously analogue TVs, so they don't actually work with the at the moment. So we're considering whether we should get rid of them and get a digital.

An emergent area of TV usage is on internet connected DM devices like iPads, laptops, and phones. These have different properties to the traditional TV in that they are portable and are somewhat independent of scheduling timetables. Participants spoke of watching BBC iPlayer while cooking or eating at the table, or of switching to the iPad to continue an interesting program in bed.

> H18MA: I watch BBC iPlayer on the iPad sometimes in bed, especially if the X Factor's on or something like that.

These portable DM devices are also often used for different tasks while sitting watching television, such as email or internet browsing, but these will be discussed elsewhere. However several of our participants had internet TV or could access it through a games console, though this was not a common activity in the sample it did point to TV usage not tied to the programming schedule, but while also retaining the sense of place that accompanies watching the main TV.

The TV is usually situated with other devices like DVDRs, games consoles, HD recorders, Sky Boxes, in what can be termed DM suites. Due to the interconnectedness of these devices, all are normally powered off the same extension socket(s) whether switched on or not. This combined with the bulk of the DM suites often makes the socket unreachable and leads to entire DM suites being left on standby, regularly or even permanently. Many of our participants were aware of this and made efforts to switch the sockets off, with one household even devising a "remote control" for the socket switch out of a length of stick .

> **H41MA:** They're all energy saving things and also like we used to… we used to like the television… Because like you can appreciate the plug's in the wall and we've got an extension lead with like 4 sockets and because everything used to be plugged into the wall, when we did the front we like sort of put an extension lead from the socket to the actual back of the telly so you got your DVD, your Virgin media, your telly. So you'd got all the plugs in there and because before they used to go into the wall sort of thing, we couldn't… , you know, we could get to it, but like we didn't really bother.

H41FAc2: It's like they'd got to be all on or all off.

H41MA: Yeah. So what do you do? You put your telly on standby, but now there's a little stick there…

Standby behaviour was in some houses deemed necessary, because of the desire to record programming on Sky boxes, these need to be powered and often result with entire DM suite being left on standby.

H46FA: We've started turning everything off.

I: Have you?

H46MA: The Sky box, but I must admit I haven't done that for a while though because…

I: It's blocked again when you get it.

H46FA: Well it's not because also as well we tape things on there. If it's turned off it won't record, so sometimes you have to leave it on so that it will record.

One household were frequent users of their very large plasma TV in the sitting room, with it always on while the three children were dressed and readied for school. Their granny who would stay behind in the house for the morning would always come in to use the sitting room after wards as the TV would have heated the room up, and would keep it warm for the morning.

This raises an interesting question about inefficient DM suites as a local heating source, which could provide context aware heating through use while, for instance, allowing the rest of the home to be heated less intensively This could also be achieved through a secondary heating device linked to TV usage.

As a channel for intervention TV offers a social grouping both spatially and in terms of activity, and seems a likely location for physical control devices. – A power off switch for upstairs light and heat?

TV provides a shared digital platform for persuasive intervention and energy feedback. These could be targeted by time, season or schedule, and related to appropriate off screen actions that could be taken in the given situations. Combined with appropriate hardware there is potential for remote control of appliances through the hub of the screen.

The portal of TV control has much greater interactive potential with digital TVs and networked devices, there is scope to build energy monitor/controller into TV architecture or more successfully through on line portals such as BBC iPlayer. iPlayer offers a superb platform for any national level role out of such an intervention type as it is accessed through devices of much higher computing power than , for instance, thermostats. Also the BBC has an internal history of technological innovations and the foundations are there for it to be an instrumental hub for energy demand reduction.

It would be interesting to see if the peak demand moments relating to TV usage (i.e. the adverts during Strictly Come Dancing) are reducing in magnitude as the possibilities of on-demand television allow people to watch programs whenever they want, or does it just cause people to watch different programmes at the same "peak" times.

An accessible power-off switch for DM suites themselves which facilitates "always on" devices (perhaps the recording schedule could control power supply) is needed to address the stand-by problem. This could be a physical or digital remote control, or even perhaps a smart phone app.

2.4 Portable Digital Media

Portable Digital Media devices as described here includes smart phones, iPads, and laptops. Handheld video game devices such as Nintendo DS are not included in this section, and neither are personal music players.

Mobile phones are especially ubiquitous in nature, with every adult participant having one and most teenagers also having one. They are used everywhere, with one participant even admitting to using them to call her daughters in their bedroom rather that shouting upstairs.

H05FAc1: That said though, mum, you do ring us from downstairs to tell us that tea's ready. [laughter].

H05FA: That's because I'm fed up of shouting, yeah.

While it was common for some parents to limit their children's use of mobile phones (e.g. "Only for emergencies"), only one participant spoke about health concerns over radiation. However she was happy to use her smart phone for non-calling activities. About half of the households had at least one smartphone user, with iPhones proving slightly more popular than Androids and BlackBerrys. These smart phones were often considered to be an indispensable extension of the users, who couldn't function without them.

H37MA: I'm completely addicted to my phone, to my iPhone.
I: You've an iPhone.
H37MA: Yeah. It's absolutely part of me.

H46MA: Oh yeah, yeah, I love it, yeah..... I use it for everything really to be honest. I'm lost without it.

This is interesting as it implies a delegation of control to the device's capabilities, further compounded by the fact that the device is literally with the user for all their waking hours in many cases. The devices themselves have a broad range of applications, from the basic phoning and texting, to internet browsing, email, video watching, social networking, and even extra features like being a torch at night.

H41MA: It's an energy saving bulb so when he comes in, you know, he's sort of like… you know, he's got somewhere to see like. Of course he goes out. 10 to 5 in the morning he rolls up, do you know what I mean? So the light's been on from… So we're going to stop that now

H41MAc1: I just take a torch out with me or something. [*cross talking*]. I've got one on my phone – I've got a flash light.

These capabilities often become embodied in user's lives, and can certainly change the way they work, communicate, and relax. Work becomes omnipresent with no escape from emails, but this was seen as a positive which helped manage the work load. One participant stated that, far from impinging on his "family time", having emails arriving to his phone actually allowed him to spend more time with the family as he could reply on the spot and didn't need to spend all his evenings sequestered in the office.

> H37FA: If he's gone somewhere for the day he'll come back and he'll sit down and watch the news with me and I'm like "What are you doing?" "I do my emails on the train," and I'm like "Okay."
>
> H37MA: In the past after a day out like that I'd come straight back, have some food and then go upstairs and deal with all the events from the day.

Smart phones were used extensively as knowledge finding tools where their proximity and connectedness made them an effortless extension of the user's reference library.

> **H41FA:** … but now I've got my phone I tend to… Like last night Alex was doing homework and we were stuck on something, so I Googled it on my phone. Before I had this phone I'd have got my netbook out. So it's just quicker. I've got the HTC.

This ability to seek new information on whim has great potential for design intervention as it bridges the contextual barriers to accessing environmentally beneficial information related (but not currently integrated) to the behaviour.

Of particular interest were cases where people uses their smart phones as a functional add on to hitherto unrelated activities, for example using GPS function while driving, or the previous example of a torch.

> **H40MA:** Very little recreation use. So I use it as an MP3 player; so I do download podcasts mostly of BBC radio programmes and listen to them in the car because I can plug it into the car. It has become an indispensable navigational aid. We don't have an iPad, but

then we use the iPhones as iPads effectively, don't we? So we'll search and look for stuff while sitting here through the iPhone.

H40FA: Yeah. I'm often on Google sort of like looking because it's just so quick rather than getting your laptop out. And like Andy says, sort of like using the maps on it and everything. It's just a tool that's got to be with you all the time. And I use the notepad on it as well. It's just sort of part of everyday living really.

This illustrates that these devices are "only" a phone in name, and in reality are more like a digital Swiss army knife – a go-to multipurpose tool for connected living. As such it positions the devices, to those who engage with them, as personal digital agents for negotiating real world interactions. If this willingness on the part of the user to interact with the physical world through a digital medium can be verified, it could provide a welcome platform for persuasive DfSB intervention. The possibilities of this, particularly relating to energy feedback and remote control, were not lost on some of our more energy and technology savvy participants.

Several houses had an iPad, which had an intermediate role between that of a smart phone and a laptop. The iPad moves around the house, transitions between different activities and people. It is shared yet personal and was seen to be used by the whole family for a wide range of individual activities, including homework, games, TV and video, music, shopping, internet browsing, email and other work related activities. In one obviously relevant example, a participant had set up online billing for gas and electricity on the iPad. In this case this is probably a reflection of the organisation and financial awareness of both of these participants, but it does provide a precedent for situating "energy reflection" in domestic DM.

I: And would you ever take it for the internet or something if you're sitting at the TV or…?

H10FA: Yeah. To be honest, I tend to use the Ipad more. I use the Ipad for shopping and….

H10MA: Yeah, but you say you don't use it and you'll quite happily do internet shopping.

H10FA: Yeah.

H10MA: You set up the internet billing for gas and electric, so you're quite capable.

These devices share a different mode of interaction to smartphones and laptops, their portable and passable nature makes them a shared portal for the family. In addition, their screen size makes them more suited to watching videos and purposeful internet use, (i.e. shopping, online forms etc.) than a smartphone. In this sense the activities are comparable to a laptop, but the nature of the interaction is far more situated, mobile, and shared.

This mobile nature leads to iPad use creeping into lots of other activities, such as watching online TV while cooking or in bed, watching cartoons with the children in different locations, and browsing the internet while sitting on the couch watching the TV. These compound behaviours are quite common, and they are highly relevant in terms of design intervention as they physically and temporally position a stream of digital activity parallel to other energy consuming activities. A second stream which could be used as a vehicle for DfSB intervention, perhaps even context aware intervention (i.e. if an intelligent system was aware of all energy being used in the home and also the location of the occupants ,relevant actions could be offered as appropriate through this medium).

Far more prevalent amongst the sample were laptop computers, with every home having one, and a significant proportion having one for every member of the family. While these were often personal and private devices (particularly when work related) in many cases a laptop was used by multiple occupants. As one would expect, a large range of activities were performed on laptops, both off and online, work and recreational.

Laptops were often primarily work devices, and used as a productivity tool while sitting at table or desk, often with a semi-permanent base in an office like a desktop computer. However their unique role, in comparison to desktop computers, is their obvious portability which leads to the further integration of digital activities into other practices. Thus we have participants regularly using laptops while watching TV (or at least in the sitting room, while the TV is turned on), which again shows how these portable DM devices can actually increase the amount of time families spend together even if individuals are perusing different activities.

H38MA: No, we use the family laptop which is actually here.

I: Okay. So it's based in the lounge then.

As mentioned there significant cross over in functionality and use between iPad type tablets and laptops particularly in terms of online and entertainment related activities which will be discussed below.

There were two main external drivers visible in the proliferation of laptop ownership, one being the parents' jobs, and the other being children entering secondary school. In many cases, while a personal laptop may have been purchased for school work, the children were also using them extensively for recreation - games, music, social networking etc. This facility seemed to bolster the dispersal of children to their rooms for study and recreation.

However receiving a personal laptop often coincides with the transition to adolescence so it's agency in the dispersal is unclear. It remains, however, an "intelligent" platform through which to reach younger family members.

H01FAc1: I have my laptop on every night.

H01mc2: I go on-line fairly regularly.

H01FAc1: From after dinner at about seven until when I go to bed, whether that's half eleven or it's three o'clock in the morning, I will be sitting in front of my laptop.

In terms of energy use there several important emergent considerations regarding Portable DM. The most obvious is the actual amount of energy consumed by the devices themselves; while in general they are quite low wattage (<20 W) they are used for significant periods of time. In the same vein is the “vampire” effect of the chargers which are often left plugged in permanently or for extended periods when not connected and continue to draw some current. This aspect was commented on by a large section of the sample, with the sensory feedback of warm chargers being noted by several.

> **I:** Do you switch off your computers when you go to sleep or do you leave them on standby?
>
> **H01FA:** Yeah
> **H01FA:** I forget mine sometimes.
>
> **H01FAc1:** I leave mine plugged in though and the box gets really hot.

Also commented on was the sheer number of chargers that have proliferated around the house, with some household making efforts to consolidate chargers into one hub.

> **H05MA:** The biggest thing I suppose in that respect is actually charging because a lot of the mobile devices we’ve usually got at least two devices charging overnight.
>
> **H05fc:** You’re awful dad because you never turn that Apple plug off. It’s always on.
>
> **H05MA:** Yeah, but there’s not always something plugged in.
>
> **H05FA:** Yeah, but it’s still on.

Interestingly these small low powered devices drew a lot of attention in terms of energy consumption for both of the reasons, but this seems to be a reflection of the fact that they, being battery powered, force an awareness of power consumption. That is, their

very functionality is transparently tied to monitoring and maintaining energy consumed. This awareness of resource use, has led to participants taking action to unplug chargers (though not necessarily reducing device use), and points towards potential of sensory feedback systems as energy saving prompts.

Also at higher conceptual level, this shows an acceptance amongst users of a finite quantity of energy being available for a device/service. Even when, in the case of smartphones, this has developed regressively where devices used have 3-5 day battery lives now only have 24 hrs. It points towards users being happy to trade off an enhanced experience (or increased capabilities) with a constrained "window of energy availability". This has implications in terms of energy reduction but also in terms of shifting energy demand where enhanced functionality matching could be coupled with a "positive" energy use agenda through the allotting of "units of use"

As seen earlier in relation to gaming, children were by and large, are extremely au fait with portable technology. This was seen to be particularly true with shared devices like the iPad use, although there were reports of children playing with, and in a couple of instance owning, smartphones.

This means that children could be potential actors in any energy consumption reduction strategy using these platforms whether intentionally or by chance.

All of these portable DM devices facilitate and enable increasing levels of online activities by allowing users to connect to the internet from the comfort of their favoured location. Commonly mentioned activities included shopping, holiday planning, knowledge gain, energy price comparison, email, social networking, TV and video, gaming, music listening and acquisition, homework, and VOIP services. While there are many interesting aspects to these activities relating to environmental issues (eg. HO5FA "looking for cheap flights online") they are by and large outside the scope of this investigation.

2.5 Social networking

Another interesting area of online activity is social networking and intra-family communications. Many of the participants spoke of using Facebook regularly both as a social platform and for direct communication with others. This was mainly, but not exclusively, amongst the younger side of the sample, younger parents and teens in particular.

H01FAc1: From after dinner at about seven until when I go to bed, whether that's half eleven or it's three o'clock in the morning, I will be sitting in front of my laptop.

I: Just browsing the internet?

H01FAc1: Yeah or on Facebook talking to someone on-line.

H23FA: Yeah, I use my laptop I suppose for emailing and keeping in touch with people and the internet, but…

H23MA: Yeah, Facebook and Ebay.

H23FA: Yeah, okay. [laughter]. But we don't have lots of gadgets, do we?

H38FA: Yeah. I'd say I use it most days. **I:** Okay. Is it for just work?

H38FA: Not for work. Personal – checking Hotmail and Facebook and stuff, searching things.

H45FA: Facebook though – you do Facebook on that, don't you?

H45mc: Not really. I go on the computer to do that.

There was also evidence of this happening in a mobile context with some smart phone users reporting using Twitter and Facebook extensively. They were even aware of the habitual, almost compulsive, nature of these social networks when accessed through the phone.

H08MA: And Jess and mum are the keenest phone users it'd be fair to say, wouldn't it?

I: Is that for making phone calls or downloading or chatting or…?

H08fc1: Yeah.

H08FA: Just chatting, Twitter, Facebook.

H41MA: Well, Sony Eriksson.

[talking about how he doesn't use it to its full capabilities]

I: And so like you wouldn't really go on the internet on it or…?

H41FA: . He browses through Facebook sometimes and…

H41MA: I browse. I just go on there and see what silly comments people put as in, you know, sort of "Don't feel very well today. Not going to college." Not Melissa, but other people. I think Facebook's got a lot to answer for really, you know. There's too much personal information put on that.

I: But addictive as well at the same time.

H41MA: Yeah.

H41FA: It's like anything else though – it's alright if it's used right.

H41MA: Yeah, Twitter you go, don't you, Mel?

H41FAc2: Yeah.

H41mc3: I'm on it.

I: Are you on Twitter as well?

H41mc3: So's Luke.

H43FA: Dad does go on Facebook on a family dog walk saying "We're on a family dog walk," which again is weird.

H43FA: Martin uses these a lot even when he's not at work.

H43MA: It's just a habit.

H43FA: It's a Facebook habit.

The concept of using these online social networks as a platform for energy consumption reduction is not a new one and would seem to have some potential in terms of generating normative and competitive motivations for behaviours. Furthermore, it would seem to offer a useful means of targeting information at particular demographic groups with shared interests and lifestyles. The key design issue would be integrating relevant actionable information into such platforms to convert the normative competitive potential into actual behaviour.

However, it would be a mistake to assume that engaging one family member through such a platform would generate energy reductions across the board, or that the entire family would be willing to use such a service together. As discussed elsewhere families are made up of independent minded individuals with their own preferences and activities, particularly as children grow into adolescence. In the same light the social networks they develop may become more personal and private, and less open to shared familial experiences.

I. So has everyone got Facebook accounts in the house?

H41mc3: Yeah.

H41MA: I'm not sure.

H41mc4: I follow Mel.

H41FA: I used to have Melissa as a friend. [*laughter and cross talking*]. She'd put a comment on it that I showed Alan that was inappropriate against [xxxx]. It wasn't disgusting. He went and talked to her about it and the next thing I'm deleted as a friend!

H41mc3: She ain't adding me as a friend.

H41FAc2: I live with you though; that's enough.

2.6 Music

Music is a form of DM which is used across almost all platforms from personal mp3 players, to phones, games consoles, DVD players, laptops, speaker docks, and traditional Hi-Fis. In addition, the radio was used in most homes, in some cases from getting up in the morning until after going to bed. Like most music, it is used as an accompaniment to other activities such as showering, cooking, and gardening.

H01mc2: When I'm washing up it's in the radio over there, but otherwise I'll plug my headphones in.

H01FA: When you're walking round.

H01mc2: Walking round especially.

Music by its very nature moves though the home from one room to another, either projected from stationary devices or by the source being carried around with the occupant. It was very common for occupants to use their own personal devices, such as iPods or phones, to play music in various rooms. This was either done through headphones, or using the very common mp3 docking stations which many households had several of.

I: Where would you listen to music?

H33MA: We've got speakers in this room and the front room.

I: Is that from a stereo or..?

H33MA: Yeah, just an old hi-fi. I wouldn't call it digital. [chuckling].

H33FA: And if you have it loud enough you can hear it all over the house. [laughter].

3 Drivers of Energy Consuming Behaviour

All energy consumption is in some way driven by motivations on the part of the occupant, however the actual energy consumed is not always directly related to the occupant's motivation but can more incidental. This section looks at some of the factors which drive these motivations, and some of the factors which give them shape.

3.1 Comfort

Comfort was a very strong motivator for occupant behaviour, and was spoken of particularly in terms of thermal comfort. Indeed all the participants' homes were centrally heated, and were all maintained to a level that was deemed comfortable by (most of) the occupants. Standards of comfort were not constant, but rather are subjective and changing depending on other factors. While it may seem self-evident to say, but people have certain comfort base lines below which they will not go unless they can't help it. This is a key principle to bear in mind when seeking energy consumption reduction (ECR), as most of our participants had the means and the access and could all afford to maintain their current comfort levels as they were. However, this doesn't preclude the introduction of alternative forms of comfort such as personal heating solutions.

> **H01FAc1:** Well, I'm sure everyone would rather have the heating on than sitting in the freezing cold just because it's there. I mean you'd like to think you're saving the polar bears and what not by sitting with the heating off, but if the heating's there you're going to turn it on.
>
> **H01MA:** No, but it does come to that point when it's really cold in the morning when you get out of bed. You want at least the chill to be gone, don't you?
>
> ---
>
> **H10FA:** I suppose when you're talking about home it's like being able to have lighting, the heating, being comfortable in our home.
>
> **H10MA**: Yeah, I remember when I was growing up at home, because you didn't necessarily have central heating, when you went up to your room you were putting a 2 bar fire on and having extra jumpers on. Now it's a modern, centrally heated home; all the rooms are comfortable. That's a big difference for those 2 growing up upstairs because they'll never know the fact that the living room is where everybody huddles

round the fire. So I wouldn't think we're necessarily flagrantly burning money, but we're not… We're aware of what's going on, but we're not going to be uncomfortable about it unless the energy bills keep going up astronomically.

H30FA: It depends how cold I feel. I mean I don't really like the dry air that central heating produces, so I try to put a jumper on and stuff like that, but there's just some days where that's just not cosy enough. So it's kind of a cosy factor thing.

The motivation to create comfort is a powerful behaviour shaping force which must be addressed in any design intervention. However this does not mean maintaining the status quo, instead less energy intensive ways of maintaining comfort must be found. These must be dynamic and adjustable to match the changing needs of participants, and to achieve this without significant changes to the fabric of the house it is likely that they must be more responsive to the actual proximity to the occupants.

3.2 Convenience

Excluding perhaps the most basic requirements of heating and lighting necessitated by the British climate, convenience is one the strongest primary drivers of energy consumption. It pertains strongly to time available and to effort required for any given behaviour, with the latter being dominant. It is also inexorably tied into the specific design and physical proximity of the appliances available, both in terms of how convenient they are to use or interact with but also in terms how much effort they save the user. At a very basic level, both of these strands can be illustrated by the habits and practices that have formed around power standby feature on modern TVs.

Where previously TVs had to be physically turned on or off at physical electrical switch on the device, modern sets can be controlled with a remote control which incorporates a reduced power-state standby control. This standby feature allows the TV to re-powered up from the couch without making the effort to walk over to the device (proximity), furthermore many modern TV sets have hidden the physical electrical switch at the side or back of the unit making harder to find and use (interaction). As such all of the participants used the standby mode to some extent (in some cases only during waking hours) as it was by a large margin the most convenient and immediate way to control the TV. The flip side of this that most TV sets still draw considerable current in standby mode, so this convenience for user consumes a lot of energy by default. Interestingly several of the participants were very aware of this energy consumption and made some efforts to reduce it switching off at the plug at night, but no one reported not using the standby feature while at home and awake.

> **H41MA:** We used to like the television… Because like you can appreciate the plug's in the wall and we've got an extension lead with like 4 sockets and because everything used to be plugged into the wall, when we did the front we like sort of put an extension lead from the socket to the actual back of the telly so you got your DVD, your Virgin media, your telly. So you'd got all the plugs in there and because before they used to go into the wall sort of thing, we couldn't… , you know, we could get to it, but like we didn't really bother.

While the standby on TV sets is a simple example of how if an appliance saves occupants effort and makes a particular behaviour more convenient that another it will often be used, the same principle applies to most appliances in the home. The traditional large "labour saving" devices like washing machines, tumble dryers and dishwashers are explicitly created for this purpose, and while none of the participants even considered not using a washing machine for clothes (the alternative, hand washing, was far too labour and time consuming), many were aware that the tumble dryer was not a strict necessity but it was often just far too convenient to pass by.

> **H01FA:** I mean using the tumble drier instead of putting it on the washing line is either laziness or lack of time. I don't think "I can't afford to do this." I think "This is not very green. I ought not to be doing this because of the poor polar bears who have got no icecap left to live on."

These particular labour saving devices are explicitly bought for their very convenience, but often this convenience driven behaviour is often far more hidden or tacit and is so strongly tied into the affordances of the available appliances and system that participants rarely even commented on it. Central heating systems for example are by definition more convenient than separate fires or heaters in every room but are rarely viewed as a labour saving device. They exhibit a lack of proximity in that they are composed of many elements dispersed around the home, each interfacing with a number of different variables (such as external temperature, draughts, doors, etc.) and thus creating a complex interaction. As such the most convenient behaviour is merely to let the system come on and heat all the radiators that are switched on regardless of whether the room was actually occupied, behaviour very common amongst the participants. Even those that were conscious of this fact admitted to not regularly making an effort to move around the home to optimise heat use.

> **H10FA:** We do have thermostats on all the radiators, but I wouldn't say that we are particular about shutting the door in like rooms that aren't very warm.
>
> -------------------------------
>
> **H01MA:** On the radiators we've got the thermostats on the radiators to adjust the temperature. We very rarely change those, do we?

The participants were keenly aware of their fondness for appliances that made life easier and the extent to which their lives were built around them; in broader sense this has been the main direction of domestic appliance design for the last century.

> **H09MA:** I'd say it's convenience, isn't it, I think. Convenience as well. It's the dishwasher, the washing your clothes. That's all convenience, ain't it? The information, like you say you could go to books, but it's so convenient, ain't it, you just press a button.
>
> -------------------------------
>
> **H05MA** Yeah. I mean, you know, we use some energy for heating the house and we use some energy for lighting the house, but I think if we were to sort of say, you know, we've taken 100 units of energy – I think the heating and lighting and cooking will probably take 20 or 30 and then the other 70 would probably be us doing things just because it makes life easier, you know, and I suppose to some extent I would include in that things like the washing machine and dishwasher.

In this case the importance of convenience is perceived as being majority of the energy use, the tasks that "*make life easier*". This points towards a positive reception toward being "allowed" to continue with the convenience driven tasks if reductions are made in terms of basics utilities like heating.

Convenience of use is a critical feature of any design intervention, both in the primary sense of the intervention itself but also in the nature of any secondary behaviour it encourages. If an intervention requires significantly more effort to use, be it cognitive load through complex interaction or physical effort through proximity and movement, then it is unlikely to succeed in changing behaviour.

If easy alternatives are available which satisfy the desired goal, they will be used. The design challenge is to achieve the main goal with reduced resource use, and make the intervention easy to use; convenient. This requires the intervention to be properly positioned in the householder's lifestyle and routines in a way which makes it easier or more engaging to use than the existing channels.

The role of proximity should not be underestimated in this, if a new intervention is not on-hand in the context of use it will probably not be sought out and used. Kitchen cupboards are full of labour saving devices like juicers and egg slicers which are rarely brought out even for those tasks.

As evidenced here and elsewhere (Drivers of Behaviour/Time), the participants often rank those appliances which make their lives easier as being the most important to them. As such they may be willing to make reductions in other more inanimate systems like central heating or showering if can be framed effectively.

3.3 Cost

The cost of energy, as relayed through utility bills and direct debits, has a complex relationship with the consumption of energy in the home. On one hand cost is often given as the main motivation in reducing consumption (see Drivers of Reduced Energy Consumption Behaviours/Cost) but on the other the cost of energy is often seen as acceptable in comparison to how it enriches householder's lives. This appears to be strongly linked to the relative expenditure on energy compared to household income i.e. if we can afford it, it's not a problem.

> **H01MA:** I suppose if you go back a few years the energy bills were a lot lower and they were only a tiny proportion of your whole income. There wasn't the motivation there to change for financial reasons. I don't think financial is actually a motivator to actually change your energy usage.

> **H01MA:** Well, I'm basically saying that even though £2000 that's still is not all … or if you take your saving from that it's actually still quite a small percentage of your whole household income. So to actually say well you're going to save 10%, 20%, well it's not going to make a huge difference to us. We'll still be pretty much in the same state and I

suppose the same with solar panels; even if we had the savings or we took out a loan we'd actually still be breaking even with the solar panels because it's about ten years to pay it off.

H01FAc1: You're thinking it's costing you rather than what effect it's having on the environment.

H01FA: I mean using the tumble drier instead of putting it on the washing line is either laziness or lack of time. I don't think "I can't afford to do this." I think "This is not very green. I ought not to be doing this because of the poor polar bears who have got no icecap left to live on."

I: So you have a feeling that you consume a lot of energy but you're not that sure why.

H05FA: It sounds awful, it's something I don't ever…

H05MA: Consider.

H05FA: No, I do consider, but I…

H05MA: Don't worry about it.

H05FA: I mean I'm not a person that worries about paying bills. We try and look at what we do. I don't think we…

When money was a more pressing concern or even a worry, participants reported being very conscious of minimising the cost of energy use. This does not always develop into a sustained habit, and can be discarded for more profligate consumption patterns when cost ceases to be an issue.

H45FA: I think sometimes it changes though, perhaps with affluence, in that when you have less money you tend to do a lot more – or I did when I lived in my terraced house – a lot more things like making sure you kept heat in – so for example having curtains that were lined and very lined and, you know, curtain the door. So anything that breezes came through you'd try and eliminate those and sausage dogs at the doors and, you know, wearing lots of clothes. I hate to say it, but as you perhaps have a little bit more money you tend to care less about those things unless it's a very, very ingrained within you. So it's there in my mind, but I hate to say if I'm cold now I just put on the heating.

H01FAc1: But for me it meant a lot when I was living on my own. Like I watched my money and I made sure we had electric on, but now I'm living back here I pay my £20 a week rent and that's it, I don't think about it.

H01FA: I think we're just lucky, aren't we, that we don't have to think about it, that we have enough money to pay that bill.

H01FAc1: Yeah, that's what I meant. Like me and Lenny had to watch what we were spending and where we were spending it and maybe some weeks we did go short, but if it was a case of I had a little one living with me I wouldn't have let it go to that situation, if you get what I mean.

Even amongst participants with an interest in reducing bills there are often more pressing issues which take precedence over just saving money. These issues often have more immediate and tangible consequences than the cost of energy use.

[While talking about using appliances to take advantage of cheaper night rates for electricity]
H23FA: That's the main one because the dishwasher and the washing machine are in the kitchen and they're quite loud and Isaac's room is above it. I don't know if it would wake him, but we used to when [Emily] was in that room and it used to wake her.

I: And a woken child is enough to stop you doing things.

H23FA: Yeah. [laughter]

H23MA: Yeah. Absolutely right, Marcus, so I'll pay the extra money. "Let me sleep, please!"

This is a good example of the manifold concerns of family life being expressed through the available contextual features, in this instance at the expense cheaper electricity use. The GTKY interviews provide good insight into these concerns but they are too varied and numerous to categorically list or predict. Thus when designing interventions, it becomes necessary to take account of those we know, but also to build in the flexibility which will allow users to fit them into their own unique lives.

Cost is not a primary motivator for everyone, thus cost based incentives should be offered in addition to other ECR strategies. Also potential savings should be presented in a form that makes them substantial enough to generate interest.

Cost driven behaviour illustrates the dynamic and shifting nature of decision making; in a considered decision cost can be a strong motivator to reduce energy consumption (e.g. after receiving a large bill) , but during the everyday actions which actually consume energy it is not as pressing a concern as the achievement of the goal. There is a strong correlation to Goal Framing theory here, where the individual generally only accesses the values and knowledge relevant to achieving a particular goal frame at that time.

For design this has several opportunities, commitment strategies could be most effective when delivered to the householder just after a bill or direct debit increase. At this point the pressing concern is reducing the bill, and the householder will be keen to take action to do this. However, the real design challenge is to keep this focus on savings in the decision making frame while they are preforming the multitude of tasks which consume energy over an extended period of time. This requires the design to increase the mindfulness of the householder during these many, often habitual, activities. The householder must be made aware of how they can reduce energy, and also be reminded regularly and at the moment of action. The alternative is for the design intervention to significantly change the nature of the interaction involved with the task so as to break with existing habits and user knowledge, or for the intervention to target high-consumption/low-interaction tasks like setting heating programmers.

As seen the concerns that drive behaviour are often too varied and numerous to categorically list or predict. Thus design interventions must take account of those we know, but also include the flexibility which will allow users to fit them into their own unique lives.

3.4 Multiple Occupants

While all energy is consumed by people, all our household were composed of several different people each with the own role to play in its consumption.

3.4.1 Different behaviours from different desires.

Much energy consumption was driven by the different needs, preferences, and routines of occupants in a shared home. This manifested itself in many different forms, but all had the shared result that more energy was being used might be possible because one occupant or other behaved in a different manner or had different needs. This is not to say that their behaviour was improper in any way, but merely that it had a noteworthy impact on energy consumption.

> **I:** And who would you say is the person who is going behind switching off lights and turning off things and…? Is there anyone?
>
> **H01FAc1:** It's Evie that doesn't.
>
> **H01FA:** Evie always leaves lights on.
>
> **H01Fc3:** My bedroom light and the bathroom.
>
> **H01FA:** And the bathroom light. So anybody who walks past switches her lights off.
>
> ---
>
> **H01FA:** Yeah we ought to be switching off and…
>
> **I:** Who is in…? Sorry, go ahead.
>
> **H01FA:** I was going to say we did have one of the devices on the television down here that switched everything off. When you switched it off on the remote it switched it off at the wall, but then we had upsets because people had set programmes to record and they didn't record because it was switched off at the wall. So that wasn't working for us.
>
> ---
>
> **H45FA:** I did this morning – I hung them on a rack, yeah.
>
> **I:** And that's a recent development since you got the space.
>
> **H45FA:** I think it's also retraining my husband because he would quite honestly take things out of the washing machine and put them in the tumble dryer irrespective of whether they needed it. No, you don't agree?

No, I think particularly jeans would be the first thing. You'd take them and "Oh, I'll just tumble dry them."

It is inevitable that different individuals will behave in different ways according to their own practical knowledge and values, and this must be allowed for in the design of ECR interventions. What is noteworthy is that the householders are often aware of this, and already make efforts to try and reduce the impact of the others behaviour, whether be it turning off lights after them or actively "retraining" them. This points towards the engagement of a "energy champion" for household or particular practice. By empowering an individual within the household to act in a persuasive role (or even a coercive role, as the relationship dictates) , and supplying them with relevant information and prompts, it may be possible to effect change from within.

What may provide some guidance for this approach is the effect of the group interview process itself, where the shared reflective nature to the discussion often made hitherto unknown behaviours visible to the rest of the family. This is due to the fact that we very rarely reflect on the majority of our energy consuming actions, particularly through the lens of energy conservation. If a design intervention seeks to get occupants to actively and consciously change their behaviour then generating this reflective self-analysis is key.

3.4.2 Comfort Gap.

In a number of cases the participants reported having different standards of thermal comfort which generally led to one occupant determining the heating settings for everyone, or led to thermostat battles where the temperature was being set up and down by different occupants.

H38MA: Well no. For feeling comfortable no, its here and Caroline's sat in my chair. The only thing about this room – I feel it gets too hot.

H38FA: But I like it hot. [*laughter*]

H38MA: So that's why I'm sat in a T-shirt and you're sat with a sweater on.

H38MA: Well, I'm quite fastidious about heating in that I don't like the thermostat to be too high, but that's basically because the house I grew up in didn't have central heating, so central heating's actually quite still a bit of a novelty for me. But also one of my sets of grandparents did have central heating and they were always… My granddad would always be checking the thermostat.

H38FA: That's a man thing. [*laughter*]. All the men in my family do that.

H38MA: I know, but my gran would go in and turn it up to 22 and then granddad would be coming along and turning it down to 17 or something.

H38FA: We do that.

H38MA: Yeah, we do that.

H38FA: We do that because I turn it up and then he turns it down and then I turn it up and then he turns it down. But my dad was the same, my granddad was the same, your granddad was the same. I think it's definitely a male / female thing.

H28FA: It's on a timer, but I go round making sure because the thermostats are at a low level on each radiator and I just turn them off as necessary and that kind of thing.

I: And would you do that like during the day and in the evenings – like go and turn the radiators up and down or is that just kind of from time to time?

H28FA: It's more from time to time. You know, if it gets colder they'll get turned up and then I try to remember to turn them back down again. [chuckling]

H41MA: The thing is, like I say, 18 degrees in an house is plenty, ain't it? Do you know what I mean?

H41FAc2: Yeah, we're all cold and he's really hot, so we have to turn it down.

H41FA: Yeah, but you know sometimes it makes me laugh. "Oh, it's cold in here," and we look at them and they're sitting in T-shirts! "Put a jumper on then!"

H41MA: The trouble is I go through the hallway where the thermostat is and if I see it on 20 I have kittens, do you know what I mean?

H41FA: Well who does that?

H41MAc1: If he sees it on 19 it's hot. [*laughter*]. It was 17 the other day. "Make sure it's on 17."

H41MA: I don't like to see it any more than 18. To my way of thinking that's plenty adequate.

I: You find it creeps up when you're not around and you come back and see…

H41MA: And you ask who's put it on 20…

H41FA: Nobody has….

This conflict over heating is very interesting in terms of effecting a change in behaviour and it raises several questions about control which are worth exploring in the development of design interventions. While it is tempting to target the occupant with the lowest temperature preferences as the bench mark for the entire home, to do so would be erroneous. As can be seen above, it is rarely this person who dictates the heating levels but rather the person with the highest temperature preferences. This relates to the level of

discomfort in being cold being greater than that of being too warm, particularly as it is easier to remove extra clothing than to get more.

It seems more promising to facilitate those with the highest temperature preferences, while gradually nudging them towards a lower heating setting combined with more personal heating (i.e. jumpers, blankets, warm lighting etc.) There is also scope to engage the person with the colder preference as a household champion to add an immediate normative influence.

3.4.3 Conflicting Activities.

It is often the case that some occupants engage in activities which are disturbing or uninteresting to other occupants and these conflicting activities lead to dispersed activity. This will always be a feature in a shared house where individuals have separate interests, but it is perhaps worth examining in terms of energy use and possible routes to consolidating occupancy.

H08FA: Yeah. Yeah because when our friends come round we generally sit round here, don't we, and we can have, yeah, a glass of wine or a meal or cups of coffee. Yeah, I think it's definitely the kitchen.

I: This is the place.

H08FA: Yeah, okay.

H08MA: Well we can't get in the lounge because the kids are watching the telly. [laughter]

H45FA: Yeah, yes. It's more of a dining room, but we tend to eat more in here. We spend a lot of our time in here either to avoid him [son playing Xbox] in there and then we're all together in there sometimes as well.

In one case a participant's mother lived in a semi-autonomous "granny flat" attached to the house, an extreme (though far from unique) example of different lives with different needs and routines sharing a home.

> **H46FA2:** Oh yeah. The reason we decided on moving in together was so that I could… you know, on the understanding I would have my own space anyway. So yeah, it's nice to be able to kind of… and it gives these time for them to be on their own as well without me around. So it works for all of us really.

This house with three generations living it gives a good indication of the complexity of occupant energy use. In this case the children were readied for school in the sitting room in front of a large energy-hungry plasma screen TV. The TV was used to keep them calm while their mother got them ready, but it also gave off a lot of heat which would make the room warm. While it may have seemed obvious to target the inefficient TV as a waste of energy, here the grandmother moved in from her flat to the warm room rather than turn the heating on in the whole house.

> H46FA2: Well after they all leave in the morning I move into the sitting room for a few hours because it's still warm from the telly being on.

The design approach must allow for these hidden, compound behaviours. They are unpredictable in nature, but there must be a general flexibility within the design intervention(s) to allow for them.

3.5 Parenting and Children

It may seem self-evident to say, but much of the energy consumed in families is driven by parents trying to look after their children's needs and desires. They are faced with a huge increase in the amount of work required and are often trying to meet these needs in a constrained time frame. The children themselves also have a direct impact on energy consumption, though at a younger age this is not often too significant. The changing nature of this driver is discussed further in the section on Continuous Domestic Flux.

H01FA: We've only recently got to the stage where we can turn the landing light off at night because for a long time it was left on all night in case Evie got up to go to the toilet because she couldn't reach the light switch. There was a long time when Liam was little that we didn't switch it off at night because he needed a light on on the landing.

H01fc3: I only like the light until I'm asleep. When I'm asleep dad comes up and switches it off, I know that.

I: Do you feel guilty using tumble dryer?

H01FAc1: But it's faster.

H01FA: Yeah, but ….

H01FAc1: If I don't do it now it won't be ready in time.

H01FA: That's right. Liam needs his PE kit for tomorrow. It's got to be dry.

H18MA: It's quite hard to be conscious of the energy you use when you've got young children.

I: Of course, yeah.

H18MA: We constantly have the washing machine on; in the winter we have to use the tumble dryer to dry things off.

H18FA: And because the children smashed the lamp in the lounge. [laughter]. Yeah, I guess it's… You know, although to anybody else we've lived here quite a long time, actually because everything happens very slowly with children around

The energy impact is not just related to tasks preformed just for children, there is also a knock on effect in the amount of time and energy left for other tasks. This is of primary concern to any intervention seeking to introduce new behaviours or increased mindfulness of energy saving, as there is very little time left for any other concerns aside from the job of parenting. Any successful intervention will have to allow for this, and if possible either reduce the workload load or, at a minimum, add very little to it. This does not mean that behaviours can't be changed, be it totally or partially, but that any changes must clearly demonstrate their worth and justify any extra time, while facilitating the needs of the family.

H18FA: When you've been sitting here with the children for an hour doing something at the table you think "Oh, the TV's still on in the other room!" I'm always forgetting.

I: So do you find that the kids obviously drive a lot of your time and activities and weekends?

H10MA: Pretty much, yeah. Mornings, afternoons, evenings.

3.5.1 Children's Health

There was evidence of significant structural and behavioural changes due to parental concern over their children's health, particularly when children were very young. These changes ranged from closely monitoring temperatures and changing heating usage to structural changes including insulation and carpeting.

H10FA: Even last week they were 27 degrees in the evenings last week.

I: Have you a thermostat in there?

H10FA: We've got like a baby thermometer and it sort of tells you when it's uncomfortable – different colours and that and it was 27 degrees in there last week in the evenings, so...

I: Was that a concern for you when you had the boys, to get that thermometer in there to keep it constant?

H10MA: Only when they were babies because a baby's temperature is supposed to be theoretically 20 and below.

H10FA: We started off with Ewan in the room above the garage.

H10MA: Which is really unreasonably cold.

H10FA: And it wasn't carpeted and we found that it was getting down to 12 degrees at night in there, so we felt that was a little bit too cold, so we've since had that room carpeted and then it was still not fantastic in there. So we've moved him out of there and that's sort of now the spare room and study. But of course if he's sitting there for a long time it can get quite cool. But as I say, that's the coldest room in the house. So we've sort of moved the boys, but now of course in the summer it's phenomenally hot where they are, so it's like you can't win.

Interestingly, several of the parents of young children used temperature sensitive baby monitors with ambient displays in the children's rooms. These seem to be consulted regularly and cause action to be taken by the parents, in contrast to the literature regarding standard domestic energy monitors. It seems to imply that where there is strong motivation (i.e. parental concern) feedback devices do generate action as they enable and support the individual to realise it. In design terms, this means that feedback without motivation is unlikely to have any effect, or conversely, where feedback is to be used that it is imperative to generate motivation through persuasive means (i.e. leveraging norms, fixed action patterns, etc.).

H38FA: And I think also last winter because it was so bad we actually had several nights where we had the heating on all the time, even overnight. If it was just the two of us we would never have done that, but because Louis' room is just so cold we had to keep it on.

I: Hmmm. What would you have done then without Louis?

H38FA: We would have just… Well, it doesn't bother us. We're quite happy, but in Louis' room because of the situation of his room and the weather we didn't have much of a choice really. We had to do it because his room was about 12 degrees without it on and that's too cold. 12 or 13 degrees wasn't it? 13 I think

These health driven changes to energy consumption were particularly true in families with young or new born children. Having a child is obviously a huge disruption in lifestyle, and leads to dramatic changes in many aspects of behaviour. Whereas previously participants had developed their own routines and practices regarding heating and hygiene, for example, in many cases these were totally reinvented to better protect the children's health and wellbeing. As these changes were generally made based on advice from doctors or health services (it is standard NHS advice to maintain temperature around 18˚C), they illustrate how parents are prepared to rescind their own standards of comfort to follow a very different set of guidelines for the good of their newly arrived children. While several of the parents spoke of growing up in cold unheated homes, none of them expressed an opinion that it hadn't done them any harm and that it would be fine their own children.

As expressed above, different heating regimes are often put in place for new born babies; however it is unclear if or when these revert back to the original heating plan.

H18FA: Yeah. Like, you know, we have to have the lights on and we have to do the laundry. That's the unavoidable, you know. I remember Linda saying something about that in their house they just wash their hands in cold water, but I can't really be washing the children in cold water. [*laughter and cross talking*]. Do you know what I mean – there's things that you kind of think while they're little, you know, they do get cold easily and that kind of thing, so we can't just all put on extra jumpers.

I: Would that have been something in the past that you would have done when it was just the two of you – putting on a jumper before you would put on the heating?

H18FA: Yeah. I mean our flat in Glasgow, I mean the living room was really pretty cold, so I would spend a lot of the time just through in the kitchen at the other end of the flat and a lot of the time in the winter we just didn't really use the living room and if you did you sat on the sofa on a blanket with another blanket around you and a hot water bottle, you know. So, you know, we'd just choose. That sort of thing.

However it should be noted that not all changes made resulted in increased energy use, in one instance a family who had previously kept their home very warm changed to a much cooler temperature based on medical advice.

I: So you've adjusted to this level that you keep the house at.

H11MA: Yeah.

H11FA: And also we had one occasion when he was little. We were in Bath at the time. He had tonsillitis quite often and one of the doctors what he said is, you know, "You keep heating quite a lot in the day, you're taking him out, he's exposed to really cold weather and that's one of the reasons he may be having tonsillitis so often and a high temperature." So we then tried to keep to a certain level and surely it did work. It did work trying to, you know, not leave the heating on all the time.

This illustrates two important features of behaviour change; firstly while comfort or thrift may have been strong motivations originally they were superseded and over-ruled by a far stronger parental duty. Secondly it shows the importance of the messenger in that most of the parents had received advice on heating levels from their GP or health service provider, in both cases respected experts.

3.6 Social Norms

Social norms in terms of energy consumption are a double edged sword, on one hand they can act as a motivation for high consumers to bring their consumption down. However for those who are at or around the average level of consumption it can act as a form of validation of their energy consuming ways. This is an issue because the current average energy consumption is still far too high, and needs to be reduced substantially to meet legal obligations agreed to by the government.

H01FA: I think we're probably about average.

H01MA: From stuff you see on the news and things like that.

H01FA: When the budget comes round and they say the average family will be spending… or, you know, they're putting gas prices up and they say the average family's bill will increase from such and such to such and such, we're usually about ballpark.

H10FA: Because our bills aren't that extortionate… They're high enough, but because we know that we're still below average, then there is a little bit of leeway in there and, like I say, its comfort and convenience over cost.

It would appear that social norms regarding average national energy consumption should only be leveraged with householders who are significantly above average in their consumption. In this situation the normative drive is strong and can be enhanced through supporting feedback and information.

For households who are already at or below national average consumption levels social norms can be still be leveraged but using different metrics and classifications. For example, instead of comparing use to the population at large it could be compared to those in your area, or to other "energy champions" etc.

H01MA: I think we're a lot earlier switching our heating off in the spring and a lot later switching our heating back on on the timer in the autumn than some other people we know.

I: And do you think, Lorraine, that you would be prepared… or how far do you think you'd be prepared to go to make changes to the family lifestyle for the sake of energy?

H40FA: Again I suppose I would to a certain extent. It's quite interesting because sort of saying, you know, "Do you feel like you're alone in saving energy?" because sometimes like you're willing and you want to save energy, but then it gets to that certain point where you think "Well, I'm not going to go that extra way because nobody else is interested, so why should I really put myself out and make life hard when nobody else cares and is just carrying on sort of like obviously using loads of energy and so forth?" So I don't know. There is a line I think, yeah.

Social norms can also be leveraged in terms other than energy consumption, and can be used to drive specific energy behaviours. This could be analogous to the man digital platforms already in existence i.e. Facebook updates; "Joe Bloggs has Switched the heating off for the summer", or Amazon - "Four people in your area singed up to the 10kWh Week Challenge"

3.7 Time

Time, or more precisely the lack of time, has a huge impact on the choices people make. As was already mentioned in the previous section on children, families are increasingly pushed for time as they try to combine family and work life. For families with younger children this is particularly the case as they often require a huge amount of care and time to be spent over tasks like eating, washing, laundry etc. Furthermore time is a finite resource and is less subjective than, for instance, comfort or convenience.

Almost all participants claimed to lead busy lives and to have little spare time available. All said that while they would be willing to make an effort to reduce the amount of energy they use, they would not be prepared or able to consider any intervention approach that consumed a significant amount of time.

I: Say like if we were going to try any devices or things to implement changes in your behaviours and your routines, would you say then that that's fairly… well yeah, it's actually quite difficult to make changes in your life and your routines?

H01FA: I think the routines can change provided there is time in the day to do that. If the routine then requires more effort in order to save electricity or whatever, then it's going to be difficult to get that into our busy lifestyle.

H01FA: I mean using the tumble drier instead of putting it on the washing line is either laziness or lack of time. I don't think "I can't afford to do this." I think "This is not very green. I ought not to be doing this because of the poor polar bears who have got no icecap left to live on."

H01FAc1: If I don't do it now it won't be ready in time.

H01FA: That's right. Liam needs his PE kit for tomorrow. It's got to be dry.

H10FA: I'd love to do a lot more, but we just don't have the time. Sort of with running a house as well and all the jobs to do, like we just don't get them done in the evenings so it's like we've knocked into the weekends and by the time we've done swimming, we've done this, we've done that it's like "Okay, it's Sunday evening and it's back to work tomorrow."

H23FA: Yeah, it would actually. I know I wouldn't be able to use the tumble drier, so don't tell me anything about that. [laughter and cross talking]. The tumble dryer's fantastic –obviously not in the summer, but in the winter time because Isaac will go through 2 or 3 outfits of clothes a day. And the dishwasher really because I haven't got time to wash. You know, it's quite… To have to stack everything and get it out of the way… So that's really useful, isn't it?

H38FA: I think sometimes I probably could walk more than I do, but it's time pressure.

Like sometimes I come home after work before picking up Louis from nursery and really the nursery's only there, but it takes me 25 minutes or 20 minutes to walk there versus it just takes me like 5 minutes to drive.

H08FA: Hmm, but we probably don't do enough. I'm aware that it does but, you know, when we turn the thermostat up a bit do we really… You know, we put the tumble dryer on because we've been late washing clothes and they need it for school. Do we really think about the amount? Probably not.

H42FA: Yeah, you're not sure that if you do something from one point of view whether it does have an effect and is it actually making a difference. So I think it would be good to get some pointers, even if it was just like, you know, something you picked up in the library and you could look at and something you could implement quite easily at home because I think it's that thing of being… well not even cash rich and time poor. You might have the money to make some changes, but you just don't have the time to implement them at all.

The success of any intervention strategy will be based on how well it aligns with the limited amount of time the occupants have. Any intervention which can actually save users time is likely to be very well received, particularly if it can also reduce the cost of energy to the house hold. Conversely, any intervention with is more time consuming, or requires a significant amount of time to learn to use is unlikely to gain a foothold in their busy lives. However, there are indications that an intervention which could achieve substantial savings, or even provided a high degree of enjoyment to the family may be accepted even if it is time consuming in nature.

Another aspect of time pressure is its intractable nature; occupants often have no choice but to do something in the shortest possible time regardless of its energy consumption. Any intervention should be careful not to punish or disallow these events as it will lead to a negative user response.

3.8 Theories of How Things Work.

Participants often illustrated an understanding of technical systems that was not strictly correct. This is a natural interpretation of phenomena based on observation but it highlights how the creation of mental models can cause a system to be used in a particular way which might not be the most efficient. In one case a participant would leave all the doors open downstairs when the heat was on in an effort get more heat upstairs. This was to combat the cold upstairs he felt was caused by the poor insulation, the fact that he was simply pouring more heat, and thus more energy, up through the roof didn't enter his mental model.

> **H18MA:** That's why don't have doors in this room and we tend to leave the doors in the lounge open and obviously the hallway…. in theory it should mean the heat rises, but it doesn't quite seem to do that.

There were also several interpretations of the nature of control between TRVs and the heating thermostat which might lead to unnecessary energy consumption.

> **H41MA:** Yeah, but the thing is, you see, with thermostatic radiator valves it's like that thermostat in the hallway really we don't need that really. Because that was in when we first put the heating in, but with thermostatic radiator valves, like I say, you can control them

The technical systems and dynamics of energy in the home are often very complex and getting even more so, and they often require an understanding beyond the tacit knowledge gleaned by most. There is a real need for the provision of easily understandable explanations of these systems, however the variation involved is enormous so to do so will be challenging. In addition, this information needs to be

packaged in such form that occupants will actually look at and understand it, and so might best be bundled into a central feedback or control portal.

4 Continuous Domestic Flux and the Role of Energy Conservation

A key impression from the investigation was the sense of continuous change and development in all of the families and their homes. It was clear from discussions about changes in family makeup, routines, practices, and the house itself, that this was an on-going feature of all families' lives and behaviour. This continuous flux was even apparent during the first months of the investigation itself, when we had children changing schools, or moving out (and also moving back in), and when new appliances were purchased, even including solar heating being installed. This is the natural rhythm of life and growth and was mirrored across the participants; however its impact on energy consumption, and thus relevance to possible intervention strategies, would appear to be extremely significant and has hitherto perhaps not been accorded the attention it deserves.

4.1 Changing Circumstances; Changing Motivations

As it can be said that life is a continuous flux, it is difficult to identify a starting point of investigation. However in this study of families, the primary moment of change centres on the arrival of the first child. Up until this point many couples reported living in smaller homes, with lower standards of thermal comfort and often levels of laundry and cleaning. On one hand this is clearly due to there being less people with energy needs, but it also reflects a sense of people being happy tolerate various minor discomforts affecting only themselves.

H23FA: I think we both, don't we, prefer the character of an older house.

H23MA: Yeah, without a doubt.

H23MA: But it was freezing in winter in the older house. You'd sit there with socks, gloves, anything you could get your hands on, you know, to keep your feet warm The rooms [in a modern house] I suppose are more sort of adaptable for modern living, aren't they, really because they're squarer. Although you've got lack of character it's a little more practical really.

H23FA: Yes. This is good for now with the young children, but we're not intending it to be forever.

One aspect of this is the desire to be a “good” parent and to provide their children with the best possible living situation in terms of thermal comfort, food, hygiene, and safety. As such many parents adopt new standards relating to these practices which are often more energy intensive than those preceding parenthood. Interestingly many parents adopted standards of thermal comfort and hygiene that were much higher than they themselves had experienced as children. Some were quite conscious of this, and felt strongly that their current standards led to a much better quality of life for their children than they had experienced.

> **H10MA:** Yeah, I remember when I was growing up at home, because you didn’t necessarily have central heating, when you went up to your room you were putting a 2 bar fire on and having extra jumpers on. Now it’s a modern, centrally heated home; all the rooms are comfortable. That’s a big difference for those 2 growing up upstairs because they’ll never know the fact that the living room is where everybody huddles round the fire.

This is just one expression of the many ways that the arrival of children and the act of parenting drives behaviour (more of which can be seen in Drivers of ECB/Parenting), but it illustrates how values and motivations change alongside family life. This change can loosely be divided into several phases, each of which has different features which contribute to energy consumption in an instrumental or motivational sense. It is important to note that all of these phases can overlap depending on the spread of ages of the children within a family, but it was more common amongst our participants for children to be within one or two of these phases at a given moment.

4.2 Babies and Young Children

In households with babies or young children almost all energy consumption is driven by the actions of the parents. It is their values and knowledge, in response to the perceived needs of the children, which determine what energy, is consumed. This is significant because they are acting not just for themselves, but also for what they feel is in the best interest of their children. At the same time there was often a dramatic change in lifestyle with one parent giving up work to look after the children. This has a twofold impact of increased daytime occupancy, and resulting higher energy consumption costs, combined with reduced income.

> **H18MA:** And there's no two ways about it since we've only got one source of income. The cost of living has risen dramatically.

> **H18FA:** Yeah and just other things like the cost of food. So yeah, although we'd made a conscious decision to sort of stretch ourselves in terms of buying the house, a lot of other things have changed over the last year and a half, haven't they, that have made it more difficult.

Furthermore parents had to learn many new set of skills and to decide between many alternative behaviours, the energy impact of which can be large. For example, several participants mentioned the dilemma of whether to use disposable or washable nappies.

> **H10MA:** Yeah, I think if you want to go back a couple of years to kind of if you were thinking about environmental, then we had, for example, washable nappies. So then you've got the argument of right, you're not landfill, but then you've just plugged your washing machine in at least once a day. Where's the saving? If you're going to do a complete balance, where is the saving?

Central to all of this is the manner in which energy is still consumed by the parents, they still make the decisions and they use the appliances. This makes them the key actors in any ECB and the necessary target of any reduction strategy. Furthermore, most parents of young children reported spending most of their time in the vicinity of them while at home, excluding naps and bedtime. This gives us a picture of centralised occupancy in one area of the home for the most of the day even though there are several people at home.

This period brings with it a significant change of context which generates new forms of behaviour with lasting impacts and, as such, is an extremely promising space to develop new sustainable behaviours. It is widely acknowledged that most new parents are financially stretched while also struggling to learn all the skills that their new role demands. If a suitable intervention approach could be found to support both of these needs, while enhancing the wellbeing of child and parents it would likely find a receptive audience.

If a parent is regularly at home during the day with a young child or children, and generally occupying one space or floor there is scope for localising energy consumption in the form of heating, lighting, etc. through some form of intuitive zonal

control. This could integrate into existing safety driven zonal controls like stair-gates or could be a standalone or smart control.

4.3 Emerging Independence, Routines and Dispersion

As children grow older they develop greater level of independence within the house, and while they are still dependant on their parent(s) for the provision of the vast majority of services they start to do some things for themselves. This is commonly in terms of entertainment and often takes the form of video games and TV but it also has an indirect effect on energy consumption in terms of moving around the house and spending time in different rooms. At the same time there was a trend in most for the children to start going to day care or preschool and, if no more children were born, for the parent that had stayed at home to start working again. At this point we begin to see a more standardised routine across the households, with regular peaks of activity in the morning and evening and in many cases with everyone leaving the house during school/work hours. This pattern carried on into primary school ages with subtle but not dramatic changes in many cases.

These daily routines are covered in more depth in the analysis of the GTKY floor plans and routines, and are discussed here only at a very high level. In the broadest sense these routines establish a pattern of energy use still driven by the action of the parent(s) but aligned more and more to external events. Thus in the mornings we have the adults generally bathing or showering before work, with one adult (in our sample mainly the mother) preparing breakfast and school lunches for the children. We have instances of the TV being turned on in the morning for news over breakfast or to occupy the children, perhaps a wash being put on or bring transferred to the tumble dryer , hot drinks being made, and food being taken out of the freezer, and many other activities. In effect, we have a huge range of energy consuming activities happening in a space of an hour or two before the house is vacated by everyone. This weekday morning pattern did not seem to change much until the children have left secondary school, but there were obviously many exceptions such as people working from home, or not working, not to mention weekends and holidays.

In a similar fashion, strong patterns emerge for the period after school and work hours with a common set of activities taking place in many households. Children watching TV for an hour or two before doing homework, while a parent (again, in our sample generally the mother) prepared the evening meal, and perhaps did some laundry or emptied the dishwasher were mentioned by many participants as being routine events. While the particularities of each families actions were quiet different, there was a strong sense of these peak energy times either side of the work and school day.

Evening routines varied with the age of the children with younger children often being bathed and in bed by 7 or 8 o'clock, whilst older children may have had different extracurricular activities like swimming happening in the evenings which might affect the schedule. These older children would often watch TV with their parents for a while in the evening before going to bed around nine or so, but equally would often spend time in their bedrooms or a games room playing video games or reading in some cases. Generally we start to see children actively driving energy consumption more through their independent activities and requests but still being led by their parents. We also start to see the increased proliferation of energy consuming gadgets and entertainment systems for the children. Yet it is still the parents who control the vast majority of the energy use, and who largely determine the actions of their children in this respect.

In this period parents are also simultaneously responding to the growing independence of their children and it was often at this pre-teen point that parents spoke of moving homes or of renovating and extending their homes to better accommodate this. These renovations were very common, and are a critical junction in terms of increasing the energy efficacy of homes, particularly in terms of heating. Electing to improve the thermal fabric of the home is behaviour like any other and subject to the same constraints and affordances, financial and otherwise, and this period of family life seems a promising one for promoting these forms behaviour.

The routines that emerge at this point form a pattern that continues for many years. While obviously changing and developing over time, there would seem to be a strong habitual element to much of the behaviours as parents seek to streamline the energy consuming activities of house as much as possible. Many mothers reported completing a huge number of tasks every morning and evening in regular routinized fashion, and while many of these are considered necessities for family living (e.g. laundry, dishwasher, etc.) there may be scope to make some energy reductions or reschedule

some tasks in a way that shifts energy demand in a more balanced way. These changes need to be supported through reminders and persuasive information in an effort to form them into lasting habits.

In many ways this is the period when many families are most aligned in their actions and most likely to communicate freely and spend time together. As evidenced by the GTKY interviews children are able to take in and contribute to family discussions and behaviours to an increasing extent. They are also more likely to become active agents of change if engaged in an appropriate manner and could also act as energy behaviour champions (and energy waste police). Whether parents would welcome this role and its accompanying "pester power" is open for further exploration, but it is likely that positive change coming from within the family unit would be a powerful force.

In families at this stage any information or feedback driven intervention strategy should seek to include the entire family unit. There was a strong awareness in many of the participants that this was a very formative period for the children, and many were keen to engage their children in environmental and energy awareness issues. In addition there was a feeling of environmental custodianship with some of the participants; a desire to take action that would be strengthened were the children to encourage it. These are strong motivations that would require guidance and information on how they could be realised, while providing a tangible level of positive reinforcement and feedback on actions already taken.

4.4 Teenagers, Adolescents, and the emergence of Independent Consumers.

A marked change in the nature of the parent child interaction seems to occur around the period when the children start attending secondary school and entering their teenage years. At this point children start becoming more independent in terms of their routines but also in terms of how they consume energy. They increasingly have their own electronic devices, such as laptops, phones, TVs, games consoles, etc., and while at home spend more time in their own rooms using them. Indeed across the sample there seemed to be a proportionate increase in the amount of time spent away from other family members the older the children got.

H41FAc2: I'm basically the same as you because ….

> **H41FA:** Yeah, but when you come in, Melissa, you go in your bedroom. Look what I have to do! That's the difference.

Much of this independence of action was driven by the increased hours spent at school, socialising with friends and studying but there is also a natural independence of mind that develops at this time. It was more common for teenagers to eat at different times and to develop their own separate hygiene, grooming and comfort practices. Hygiene and grooming practices in particular become far more energy intensive especially for girls, with personal appearance gaining in significance at this time.

> **H05FA:** But if you were here you are actually a gross consumer because the bills went down dramatically [when you moved out].
>
> **H05FAc1**: That's my hair straighteners.
>
> **H05FA**: And hairdryer.

While most of the teenagers and adolescents sampled were reasonably aware of sustainability and environmental issues, none were advocating or visibly performing RECBs unless at the strong behest of the bill payers

> I: What would you say energy means for you? Is it survival then or…?
>
> H01FAc1: No, it's not survival. I could live in the woods, catch my own food, I could do that, but I know a lot of people couldn't. But for me it meant a lot when I was living on my own. Like I watched my money and I made sure we had electric on, but now I'm living back here I pay my £20 a week rent and that's it, I don't think about it.

It should be said that parents still did the majority of domestic chores, and were responsible for most of the laundry, cooking, and cleaning, and as such they are still the primary consumers of energy. However there was a sense that older teenagers and adolescents were becoming satellite energy consumers, in that they often moved around the periphery keeping their own hours and consuming energy in a semi-independent way. This is facilitated by the fact that they had their own energy consuming devices in their own rooms and could do work or entertain themselves away from the rest of the family. There were even reports of teenagers watching the same TV program in a different room to rest of the family.

It seems difficult to specifically engage older teenagers directly in RECBs, and is perhaps best done through a family wide umbrella intervention strategy. However such a strategy must allow for the different habitation patterns they practice, particularly their desire for personal space. One potential route is to empower them as house hold champions, and while it is probably true that they like to tell their parents what to do, engaging them into any activity seems tricky and would need to be developed further.

5 Reduced Energy Consumption Behaviours (RECBs)

Most participants had already engaged in a range of activities intended to reduce their energy consumption. These stemmed from a wide range of motivations and occurred across different practices but could be grouped into the five different behaviours explored below. These provide some insight into what RECBs are already being attempted and what are the pertinent characteristics of them.

5.1 Switching Off

Switching appliances off when no longer in use was one of the most common RECBs mentioned by participants. Many appliances are left turned on or in energy consuming standby mode while not actively being used. Standby mode in particular is often a design feature of appliances intended to allow quick and easy switching on, especially through remote controls. Also the nature of some appliances like lights, means that people are don't switch them off as they need or want to still use the appliance as the move away from the switch i.e. the light from one lamp is needed to get as far the next room.

Many of the participants made a conscious effort to make sure these devices were properly switched off. This was particularly the case with appliances which provided a strong visual indication that they were still in use especially, i.e. lights. Often this switching off was done in a concerted and systematic manner at set times of the day, such as before leaving the house in the morning or going to bed. The key reason for these switching off tours was the awareness that these appliances would definitely be not be used for an extended period and thus would not be needed to be in instant readiness. This activity was often considered to be a chore and in some cases a constant battle as it required effort, time, and mindfulness to complete.

> **I:** And how willing or easy do you think it would be to make changes in your lifestyle if you were to try and become more environmental?
>
> **H28FA:** I'd certainly try. I think we've tried to put a couple of things in place – things like when we go to bed we make sure we switch the telly off at the wall and that kind of thing. It's not everything that gets switched off at the wall, but there's a few

things we try and switch off at the wall after we've finished using them – like the cooker and that kind of thing.

H30FA: I've been making an effort to turn the lights off more because it's something I'm not very good at. In fact, I noticed my electricity bill has gone down for about the past three quarters compared to the year before and that was just me and Freya living here. So something's made a difference.

H33FA: Yeah, I kind of think of heat. But then I said that and I think one of the big things I'm always saying to the children is "Why are all the lights on in this house!" [*laughter and cross talking*] and I go round switching all the lights off.

H41MA: They're all energy saving things and also like we used to… we used to like the television… Because like you can appreciate the plug's in the wall and we've got an extension lead with like 4 sockets and because everything used to be plugged into the wall, .. So you'd got all the plugs in there and because before they used to go into the wall sort of thing, we couldn't, you know, we could get to it, but like we didn't really bother.

H41FAc2: It's like they'd got to be all on or all off.

H41MA: Yeah. So what do you do? You put your telly on standby, but now there's a little stick there… [*pointing at a stick used to reach the socket switch*]

I: And do you use it?

H41MA: Oh yeah, yeah. We make a point of it.

H09MA: And we've picked up on, you know, this thing with the standby, all the televisions on standby and actual electricity use and we've got… I got a device to turn off… Didn't we tell you about it before, didn't we? I've got a remote that'll turn off the plugs at the sockets to stop the television, the computer and the stereo being on standby all sort of night and we quite religiously will turn that off.

These switching off practices and "tours" were fairly common among the participants, but without further monitoring it is difficult to ascertain their impact on energy consumption. What is notable about them is that they display a concerted effort to try and reduce energy consumption through waste. This motivation to act could perhaps be redirected to other energy wastage which might have a higher impact, for example closing windows while the heat is on. Such transference of intent could be achieved through suitably framed information and prompts

Notably, devices which provided a sensory indication of being on or on standby elicit more attention, this relevant not just product design but for any intervention targeting standby.

It would also appear that there are a number of major causes of not switching off appliances; these include forgetfulness, unintended changes in activity, proximity to switches, and convenience (or laziness) and a desire for continuity. Design can address many of these issues through a number of different avenues; for example forgetfulness could be targeted through reminders or alerts, or through smart sensing and automation. Proximity can be targeted through remote control and through situating interventions in appropriate locations that tie into existing routines, i.e. a bed side "eco-switch". Any such centralised or automatic intervention would need specific hardware to be developed and distributed to effect the switching-off,

5.2 Energy Frugality

Energy frugality can be viewed as taking care to use less energy while using the appliances, either by aggregating tasks, using the lowest energy settings, or being mindful of unnecessary wastage. It requires an awareness both of how the energy is being used by appliances and systems, but also what measures can be taken to reduce or diffuse this. It is an extremely desirable behaviour to cultivate as requires no new appliances to be purchased or structural changes to be made to the home, nor does it really require any curtailment of the desired output from those appliances. It does however require mindfulness and planning and, as discussed previously, these are difficult to introduce into busy family life without prior establishment.

Quite a few participants spoke of practising some form of energy frugality, but generally it was in connection to a small number of specific behaviours of which they understood the impact or had been made aware a more efficient way of achieving it.

> **H33FA:** I guess I'm more bothered about that. So if I've got a cake to make or I've got vegetables to roast I do it at the same time as I'm doing something else. I'm really quite particular I guess about not putting more water in the kettle than you actually need and I get really annoyed when my brother comes round, for example, and he just fills the kettle up! [laughter] I find it really difficult not to say "How many people are having a drink?" and I'm always switching the kettle off at the mains.
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> **H39FA:** We think very carefully about putting the heating on, which is partly for sustainability, but it's also partly the cost as well. We're rather skin-flint.
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> **H40FA:** I think they go through top tips of sort of saving energy and one of them was like don't boil the kettle, walk away and do something else and then come back and re-boil it. And I think they were showing that and had about 5 more cyclists on the re-boil, you know, and now I never do that, which was one of my bad habits and now I'm very conscious of it. So I always like hang around and make sure I make my cuppa without getting distracted.
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> **H08FA:** I do press the eco button on the new washing machine we've got. It's got an eco-button, so I press that.
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> **H08MA:** Yeah, I suppose that's a good example of the sort of thing we do. We like buy a device that has an eco-button without necessarily knowing what on earth the eco button did.

There a number of factors needed to introduce energy frugality behaviours into the house hold; awareness and understanding of the impact of the energy use, knowledge of more efficient practices, and the mindfulness and foresight to implement these. While design intervention could seek to build these elements into different behaviours around appliance use through situated informational and/or other means, the major challenge is

providing the right advice to the right people at the right time. Each family has its own practices relating to different appliances and each are seeking a different result, it thus becomes difficult to provide very specific useful information. However it is possible to provide more general appliance related guidelines but these must tap into the user's motivations at the right moment to affect behaviour.

5.3 Monitoring Use

Monitoring energy use does not in itself reduce the amount of energy consumed, but it does provide an awareness of how much energy is consumed by different behaviours. It involves actively examining energy use, either in general practice or through specific monitoring channels such as smart meters and bills. It was or had been practiced by most participants particularly in the form of billed usage and plug-in electricity monitors.

> **H05MA**: [speaking about plug-in energy monitor] I think what it is, it changed our behaviour initially because you were constantly keeping an eye on it and then after 2 or 3 weeks for some reason it got buried behind a fruit bowl and if it wasn't there showing you , you just took your eye off it and forgot about it.
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> **H01MA:** A little while back we bought one of those meters that goes on the mains electricity so we could see how much electricity was being used and that was quite interesting because you could see what was soaking up… you know, big peaks.
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> **H11FA:** Yeah, we've got a smart meter. So things that [put it up], you know, I can show him. "Look, you have been in shower this long." You know, when he's in the shower I can say "Look, this is going red."
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> **H37MA:** I do keep an eye on it because they give you fancy graphs now on the bill, the data, so I can do some comparison there and if things are going northwards I'd want to know why. I'd look at it, yeah
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H05FA: However, I did an experiment of having a shower and putting the plug in and there's actually very little difference. [cross talking].

I: Have you got a little monitor thing? A little energy monitor thing was it?

H05FA: No, literally I did just put the bath plug in to see what happens when you have a shower and there's no difference.

Monitoring use is a preliminary step in many RECBs , and can have two main impacts depending on the motivation of the viewer. To those who are highly motivated to reduce energy consumption it is the primary feedback channel that alerts them to high energy consumption and directs their actions. However to those with less motivation or less scope for energy consumption reduction (real or perceived) it often has a short term effect where an initial response fades as the information's impact is forgotten.

5.4 Seeking Alternatives

In some instances when participants were aware of the amount of energy used by a particular behaviour they would try to find new, more energy efficient ways of achieving the same goals using other appliances at their disposal. This depended on the availability of another means achieving the goal or behaviour being in the home. Again this a very desirable behaviour in term of energy reduction as requires no new expenditure, but it does require the occupant to have an awareness of the relative energy use of different appliances and ability to imagine a new way of doing something. In some cases this very obvious, i.e. drying clothes on a rack rather than in the tumble dryer, but in others it often requires initiative and detailed comparative energy feedback from an energy monitor.

H01FA: So there are things like we have changed from having that monitor – that when we're cooking vegetables we don't heat the water in the pan, we heat it in the kettle because it takes the same energy but for a very short period of time.

H45MA: Well, one thing recently – we've not been using the tumble dryer. Because we've got the spare bedrooms we've got space to dry out clothes without them sort of being around the house too much

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H05FA: [changes made from having an energy monitor] I do. I do. I will heat drinks up in the microwave now rather than put the kettle on.

Where there is a motivation to reduce the amount of energy consumed, the provision of a range of low energy alternatives to prominent behaviours is a key enable of RECBs. Such comparative information is not readily available to householders and should be provided in a concise accessible form.

5.5 Structural Changes and New Appliances

Many participants reported purchasing new more efficient technologies to reduce energy consumption without having to drastically alter their behaviour. While this often requires substantial expenditure and is not an option for all by any means, it is frequently the most effective way for a household to reduce their energy consumption in the short term. However it is important to note that when technological or structural improvements have been made there is still often the scope to change the underling behaviour to further reduce it energy consumption. For example, while it is possible to buy a AAA rated tumble dryer it will still consume more energy than drying clothes on the line or on a rack. In other cases the technological improvement can be a necessary addition to behaviour change, as in the case of home heat insulation.

I: And did you make any changes in your behaviour after that or have you made any changes even aside from that to try and reduce the amount of energy you use, or is it a factor that doesn't need like to be thought about that much even?

H23FA: We've bought a better heater, a more efficient heater.

H23MA: Yeah, a more efficient heater, one with a proper thermostat that works for the office.

H38MA: Yeah. When we bought the appliances for the house we tried to go for ones which had a good energy rating – like the fridge, like the washing machine. I think the cooker was as well; it had quite a good energy rating.

H41MA: We've gone a long way. Like I say, we've gone a long way sort of thing. When we did the front room it was like energy saving bulbs sort of thing, you know, because… I know like in here obviously it's bright enough, you know, but it could… Like for example, the old lighting used to be similar to that. That's obviously different to what we used to have, but we were sort of like running 40 watt bulbs, do you know what I mean, so you've got 200 watts there, but them bulbs there just on their own they're 5 watts each, so you've got 25 as opposed to 200.

I: Okay. What sort of things have you done?

H05MA: Insulation and all that sort of thing. We did look at solar photovoltaic tiles, but they're not suitable for this house.

H08FA: And actually to be fair… Because our washing machine broke so we had to buy a new washing machine and, to be fair, we did look at the energy ratings of them. So we did look at the energy rating on the new one and we ended up buying one that was £100 more than the one that we'd chosen largely because it had a better energy rating and also the programmes were shorter. So when you looked at the running cost it did influence us

The act of purchasing these improved technologies is a behaviour in itself, albeit one with often only a single instance, and is subject to the same factors that drive other behaviours. As such it can be promoted through intervention in the same way, though in many case the contextual barriers, such as lack of money, may be insurmountable even when motivation is aligned.

Furthermore these technical acquisitions generally will not solve the problem alone and will still require the introduction of more sustainable behaviours to further reduce energy consumption to the requisite levels.

6 Drivers of Reduced Energy Consumption Behaviours (RECBs)

6.1 Introduction

The interviews uncovered a number of drivers behind participants desire to reduce energy consumption. These were a mixture of ideological reasons and experienced learnings, but foremost amongst them was a financial motivation to reduce the cost of energy bills. There are always some limitations to information gained from a reflective interview like this, which doesn't necessarily convey the dominant motivations of participants while they are actually performing the activities which consume energy. Nonetheless, these drivers are the ones which would appeal to occupants particularly in the uptake of any design intervention.

6.2 Cost

The rising cost of energy bills and their proportion of household expenditure was far and away the strongest motivator to reduce energy use amongst participants. As shown previously (see Drivers of Behaviour/Cost) cost has dynamic relationship with energy use, often dependant the percentage of income spent on it, and would not be a strong motivator for everyone. However, in this sample most people were keenly aware of the cost and very eager to make some savings if possible. Indeed many of the participants listed it as their only real motivation to reduce energy consumption in the home.

> **H01MA:** We do actually because we did a… Funds are a bit tight at the moment so we actually checked how much money we're spending on each item and we're spending about £2000 a year on energy for gas and electricity.
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> **H18FA:** So it is quite hard to feel empathy sometimes to saving energy other than for the sake of saving money.
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> **I:** For the immediate impact.
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> **H18MA:** Yeah. So that's the main driver – it's probably to save money I think. We are conscious of it, but the reality is…

H18FA: No, I think largely it's money. Yeah, as I say, I would like to be sort of I guess more environmentally friendly, but…

H23MA: Well, it's the ability to run the appliances really and to keep warm. I think especially now you're certainly more aware that when you have the heating on it's costing you, whereas before you never really used to think about it. I suppose it wasn't on very often and plus when you had two full incomes coming to the house it really didn't matter and was a very small element of your overall income anyway.

H45FA: Yeah, definitely having spent years in my life with not lots of money and saving money and conserving heat and various other things it's actually, I think, really important. You know, you can find a way of drying clothes without using a tumble dryer when there's heat coming out of radiators.

The impact of energy cost are felt especially by families with young children, this is compound by the fact usually one parent has stopped working with the arrival of the child and is now spending a lot more time at home. This lead to a significantly reduced income combined with increased energy bills. Furthermore new parents have so much on their plate that it can be difficult take energy reduction in to account while trying to fulfil their new parental role. This could point to a pre-natal design intervention strategy, which could seek to raise awareness and institute new reduced energy consumption behaviours prior the birth of a new child. Obviously this is a difficult problem space to gain a foothold in and such an intervention approach would have to be extremely engaging to gain a positive response.

H39FA: We think very carefully about putting the heating on, which is partly for sustainability, but it's also partly the cost as well. We're rather skin-flint.

H39MA: Yeah. And of course then the lights that some people leave on and don't turn off when they leave the room and then the machines that might still be on that's in some room.

The nature of how this financial motivation expresses itself is a key concern for any intervention strategy. It would appear that it varies across the sample, with some self-described "skin flints" claiming to be conscious of expenditure all the time and taking appropriate action on an on-going basis, whereas others would admit to receiving a rude awaking with the quarterly bill. This range of awareness and positive action requires different design approaches, or at least a design approach which supports both continuous action and more infrequent but dramatic energy reduction.

H18MA: I think we sort of get a wake-up call every 3 to 4 months when we see the bills.
We pay by direct debit and it's changed a few times I think. When we first arrived obviously the previous family had used a lot more energy than we did, or I thought they did.

H23MA: Well it just went up from we were paying £35 a month each for gas and electric and we went with the electric then up to £80 a month because we just…

I: Combined?

H23MA: So I think it's a combination of having a young baby, plus a very cold winter, plus me doing an awful lot of work from home and the bills just went through the roof really.

I: Uh-huh, shot up.

H23MA: Yeah, very much so.

I: And were you aware of it as it happened or did you just get hit with an annual, at the end of the year kind of "You're this much off "

H23FA: I think we knew we were using a lot.

H23MA: But it didn't really hit home until they said "Actually…"

H23FA: No and then when you get the bill you think…

H23MA: Yeah, [that's the moment].

H23FA: Yeah, definitely. [chuckling].

H23MA: It's like "This surely can't be right! Check the meter. Oh, they're right." [laughter].

H23MA: "What have we been doing?"

I: Was there something that prompted you to think about that?

H28FA: We had a huge electricity bill. Well it was huge for us and I phoned up and said "There's got to be something wrong with this!" and "What else can we do?" and the guy suggested that we switch things off at the wall. Actually the bill was wrong, [laughter], but, you know, even so we thought "We'll give it a go," and we were really good for quite a few years and it's only been the last year really I suppose it's really kind of petered off a bit.

The dramatic impact caused by increased bills is a very strong prompt to engage in REC behaviour and should be fully utilised by any design approach. It could lend itself to an intensive "energy boot-camp" approach where occupants could be engaged into a whole series of actions involving target setting and commitment strategies. It is crucial that the durational aspect of these activities are maintained through prompting and support, as otherwise it is likely they will fall away as the impact of the bill is lessened in time.

Such as cost focused approach requires the use of significant and meaningful metrics to sufficiently engage users. For example, it is unlikely that users will be motivated not to use the oven to heat their dinner if promised a saving 7.3p by using the microwave. Extensive user testing of any cost centred metrics is required to ascertain what is meaningful to participants.

6.3 Efficient Design

Distinct from other motivations to reduce energy use was an appreciation of energy efficient design as expressed by some participants. While certainly strongly influenced by reduced cost this was also based on an attraction to elegant design and low energy systems.

> H23MA: Yeah, very much so. If we had the opportunity to build our own place…
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> H23FA: Hmm, you'd love to do that, wouldn't you?
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> H23MA: Yeah, I would do. [cross talking]. But yeah, the driving force for that [for me] would be to get a property that is pretty much self sustaining because I remember going to see some architects, a client of ours, to design a building and we had like a central sink for the air. So it would draw the air in from outside and either heat or cool the air and you had vents and a ventilation system within the building and they'd just draw it through. You know, very, very low energy cost. It's just the movement of air and just, you know, expansion and sort of cooling of the air really.
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> I: And is it the financial efficiency of it that appeals to you or is it just the elegance]that you're not…
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> H23MA: Yes, it's the concept. Yeah, I like the idea of the workings of it. You weren't quite so keen on the reed bed system, were you, for the sewage treatment. [Laughter and cross talking]… I like the idea of it just to see what else we can use to try and sort of cut down the energy use really.
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> H08FA: And actually to be fair… Because our washing machine broke so we had to buy a new washing machine and, to be fair, we did look at the energy ratings of them. So we did look at the energy rating on

the new one and we ended up buying one that was £100 more than the one that we'd chosen largely because it had a better energy rating and also the programmes were shorter. So when you looked at the running cost it did influence us. So we paid £100 more for that washing machine because the washing cycle was shorter and we looked at the overall cost… You know, it gives you an overall cost of running and that one was £48 and the other one was £102 over 2 years, so we thought, you know, you're paying £100 more but actually within 2 years you've broken even and you've got a more efficient machine

While this may not be a universal motivation in any terms, it does seem relevant to the desire to engage with any new design intervention. Accordingly, the workings and reasoning behind such interventions should be made accessible to the user to appeal to this motivation. Obviously such an explanation is required in addition for a number of other reasons, such as ensuring proper use,

6.4 Environmental Concern

While many of the participants were aware and concerned about the environment, relatively few gave if as a major motivation to reduce energy consumption.

H33FA: Yeah because I do kind of buy into the idea that we all live on this planet, that it's loaned to us and we care for it and I have children who are going to live beyond my years and I want them to have an environment that they enjoy.

H05FA: I don't do it for those reasons though. You do. I mean I was always brought up with a family that did that sort of thing.

H05fca1: That's like grandma's only doing it for money. [laughter and cross talking].

H05FA: No, there's a difference between photovoltaics and recycling and composting and doing all those things that have been taken as granted because that's what my mum did in the '60s.

I: For ecological reasons therefore.

H05FA: Hmm, yeah.

[Speaking about personal effect on environment]

H09MA: I think my idea's probably you don't know whether you individually will actually have an effect, but if you don't do anything, then you know for certain that you're not going to have any affect at all, are you, and you're just not going to be… I think on our own it's probably… You know, it's going to need a lot of people… You sort of hear these stories about people not getting involved in recycling and you kind of think "Well, why would people have that attitude?" and, you know. I mean we're quite conservative with electricity in that we try not to use… We look for energy saving devices and we look… And I can't understand why people wouldn't do that, but I suppose you do realise people are lazy I suppose, aren't they, and it's an effort and…

H01FA: I mean using the tumble drier instead of putting it on the washing line is either laziness or lack of time. I don't think "I can't afford to do this." I think "This is not very green. I ought not to be doing this because of the poor polar bears who have got no icecap left to live on."

While environmental concern appears not be a very strong motivating REC behaviour at the moment it should not be disregarded. It is an issue which will likely continue to grow in relevance over time, as has a permanence that financial motivations do not always sustain. It may be possible to strengthen environmental concern through persuasive design by the provision of information and the leveraging of norms and parental concern. However it should not be the primary design focus but rather a supporting or optional path of engagement as it remains an intangible concept for many.

6.5 Upbringing

Quite a few of the participants spoke of being raised to be very conscious of energy use, generally for financial reasons. What is particularly interesting is the long term nature of this awareness, which comes across being completely ingrained in these participants.

I: And H40FA you were talking about your parents having a very frugal I suppose in terms of energy use and having the house cold and things like that. Do you find that that could impact on the way you'd consider making changes to reducing your amount of energy or do you think it would make you more willing or less willing?

H40FA: I don't know. Neither really. I don't think I'd be less willing. I've obviously been brought up sort of conscious of all those things, but I haven't rebelled and gone the opposite way.

H41MA: But yeah, going back to the energy side of things, I think… The energy side of things I think with myself it's sort of stemmed from my parents sort of thing. You know, like your parents always used to tell you "Turn the lights out," do you know what I mean? I tell these but I'd say not so much, but I used to tell the kids to turn the lights out when they'd finished because you can imagine in a house this size, you know, it used to look like Blackpool illuminations, do you know what I mean?

I: What is the main motivation to do those changes? Is it a general worry about CO2 emissions and all that or is it…?

H05FA: It's the way I've always been I think, yeah.

H40FA: Grew up sort of being very conscious, yeah. But not because it was a waste of energy, because it cost money. Whereas obviously views are different now.

This illustrates how lessons learned and repeated in childhood can have long term effects, and points towards design interventions aimed at engaging children into

RECBs. This is obviously an area requiring a high degree of ethicacy and tact, but there is nothing inherently wrong with empowering children to reduce the family's energy use. Many parents would acknowledge the strength of "pester power", and in some ways change might come more successfully from within the family. An obvious platform for such a platform would be video or online gaming which is already the dominate personal and social activity for many children.

7 Barriers to RECB

7.1 Introduction.

Even though their participation in the study illustrates a willingness to reduce energy consumption amount the participants, there were still a large number of real and perceived barriers which reduced their ability to do so. This section looks at these factors through this lens, even though a number of them are related to those covered in previous sections.

7.2 Aesthetics of Low Energy Technologies.

A number of participants expressed distaste for the aesthetic quality of many low energy technologies. This is particularly true where a low energy technology is purely functional in design, but this is at odds with the majority of domestic purchases which are chosen with some aesthetic or sensory consideration.

> **H23MA:** Solar's something I've looked at although solar panels are not particularly pleasing. You can get tiles, kind of black tiles, but I think the wiring on those is quite [detailed] and quite expensive again on each individual tile.
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> **H39MA:** I can't remember whether it was the Energy Saving Trust or... and you can get it looks like thick wallpaper but it's some sort of insulation. And so that's in fc's room, but it's not… I don't think a lot of housing associations use it and it's not particularly attractive and we thought "We don't really want that in our living room," because the joins and things were… And you can't put things through into the walls through it because they don't attach properly with it being quick thick
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> **H05FAC1:** I'd say another thing is like I think we'd be more willing to use… I know most of the lights in the house are energy saving, but we'd be more willing to use them if they were better. You know they take quite a while to warm up? I found when I was doing art homework and stuff… I had a lamp in my room that was energy saving and I'd have to turn it on half an

hour before I needed it because it took that long to get bright before I could actually use it and see properly.

It is crucial that any design intervention be designed with aesthetic considerations in mind. This is not just a subjective point of departure, but a well-executed design gives a perception of quality and credibility. Nor is this a purely visual consideration, the other sensory aspects of any design must also be deemed pleasing, or at least inoffensive to the users. This includes any lights, sounds, smells, and textures used and any transitions thereof.

7.3 Comfort Baseline

Strongly tied to Comfort as a Driver of Behaviour but in an inverse sense, it was made very clear by many of the participants that there was a level of comfort that they considered to be a minimum and would not be happy to go below. This was often talked about in terms of thermal comfort but more so in a general comfort of living. Interestingly this was often mentioned by participants who were already very conscious of their energy use and indicates a considered opinion based on serious thought.

H10MA: Well, we obviously… I mean I'm just talking coffee table conversation. You guys know more than I do, but I think if you want to be really kind of well-informed there's lots of places you can go and look. I'm not that into doing that. I'm quite happy with where we are sort of trying to minimise use, but not going completely out of your way to be uncomfortable, shall we say. I think we strike a reasonable balance.

I: So you're saying you're aware of how your actions are affecting, but then at the same time you also have lives to lead.

H10MA: Yeah, exactly.

I: And you want to maintain a quality I suppose.

H10MA: Exactly. You can't expect the human race to go back into caves, for example. It's just not going to happen. How you educate people that's a different argument. I don't think you educate them by fear. You educate them by a genuine education process.

H11FA: Yeah. He says "Well I have to have the lights on," you know, and you have to have this and that and if it's really cold you can't really stop putting the heating on and that kind of thing.

I: But you obviously are kind of trying to keep it to a comfortable minimum I suppose.

H11FA: Yeah.

I: And then how willing do you think you would be to make changes in your behaviour or in your lifestyle in order to become more…?

H40MA: That's a tough one. Somewhat, there's a certain level of comfort beyond which we probably wouldn't want to go. I mean I prefer to look for options / solutions that are more sustainable. I mean it depends. I mean I would consider for instance giving up fruit and vegetables out of season and that sort of thing. Energy use? I mean there's some things we use energy for that we wouldn't want to stop using energy for.

H43FA: But I mean things like… Because I have an electric shower every day and maybe using the shower that runs off the boiler would be more economical. That sort of thing yes, I could do sure. But if you started saying "Don't use your tumble dryer and put 60 watt light bulbs in that give you a dingy light," then I would just say "Actually, no."

In design terms this presents a real challenge of ascertaining what is the comfortable minimum, as can be seen above this is different for everyone and varies with seasons,

weather and energy level. Any design seeking to reduce energy consumption will have to engage users in this discussion, and adapt to their particular preferences while allowing short term increases in energy usage. Such a design would need to offer choice about which areas to target and to what extent, and to maintain a dialogue with the occupants about what reductions are viable for them while levering persuasive design mechanics to push the envelope of acceptance. This is likely to take the form of persuasive digital agent which would have the scope to handle such a task, but it is not impossible for these attributes to be mirror in some form by a "dumber" intervention.

7.4 Conflicting Occupant Behaviour

[For a fuller analysis of the role and challenges related to this area see Drivers of Behaviour/Multiple Occupants.]

It was made clear during the interviews that any energy use preferences or unofficial energy policy in a family home was not shared unanimously by all occupants. This can be viewed as a serious obstacle to introducing RECB as it increases the numbers of actors needed to comply with any given behaviour change. Often as not, it is not some ideological departure that causes different occupants to behave more or less energy intensively, but rather it is individual lifestyles and preferences. The following examples are all taken from one fairly typical family to illustrate the many various impacts that conflicting occupant behaviours can have.

> **H05FA:** And I refuse… You made us by a blooming tumble drier and I refuse to use it.
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> **I:** Would you use it for your kit?
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> **H05MA** No. The tumble drier probably gets used maybe once every two months.
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> **H05FAC1:** When me and Jenny sneak our stuff into it.
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> **H05FA:** That's the problem, they sneak their stuff into it. It's going. I'm throwing it away.
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> **H05FAC1:** We've got one of those meter things, haven't we?
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> **H05MA**: We have got one of those meters, but somebody unplugged it and I've forgotten to put it back in.
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> **H05FC2:** That was Mary.
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> **H05FA**: I mean normally I would have the back door open tonight as well because I just like air in the house, but Harriet has Raynauds. I have every single window open normally.
>
> **H05FA:** I mean you've asked for the heating on tonight and I'm boiling hot and you're freezing cold.

For design it brings greater challenges to try and meet the needs and wants of so many participants at the one time. Various strategies could be used, such as the allocation of energy credits to individuals to "spend" as they wish, or the apportioning of control to an energy champion. To some extent energy feedback devices could be used to "police" energy use and relate it to the bill payers (generally the parents). But whatever the design approach it must factor in that it will be used differently by all members of the household. Indeed this could even be a realistic starting point, to allow each individual to interact with any intervention in their own manner while being provided with individual feedback.

7.5 Confusing Information and Tariff Complexity

One of the biggest barriers to understanding energy use was the confusing manner in which energy information is relayed by providers. It is not just the disconnect between units and kWh and actual energy usage but also the complexity of the way tariffs are relayed to the consumer. There was a sense that this was often a deliberate ploy to keep consumers paying more than they need, and it certainly would have an negative impact on demand shifting as most participants struggled to understand the nature of the their own usage and how it would align to any price plans like Economy 7.

> **H18FA:**You know, when you look at tariffs I find it really confusing because it's per unit not per kilowatt or whatever. I tried looking at it to change providers and I just didn't really understand what it was I was comparing, which I don't know whether that's part of their plan – to confuse us all completely. I just thought it was a bit of a shame, you know, because I was trying hard to work it out and I thought "If I can't even work it out, then how are you meant to know if you're making the right decision?" and I ended up not changing, which is maybe a mistake.

I: So they succeeded.

H18FA: Yeah, they put me off completely.

H18FA: Yeah, it would be quite complicated, wouldn't it? But I think even if you could just work it out based on… Because our electricity bill is in units and then there's the day rate and the night rate and then there's you pay a certain amount per day standing charge and then what you use over and above that and it makes it really just so complicated. And, you know, we're reasonably educated people and it's complicated for us so, you know, to people…

H23FA: We don't use it in the summer, but now the weather's not very good and… Yeah, washing. We do an awful lot of washing, don't we, but we do have… The tumble dryer's on a timer. We have Economy7, but then my dad was telling me – it was only recently, wasn't it? – that apparently Economy 7 is more expensive on the day rate. I don't know. We need to look into it.

I: And would you know that offhand or is that a standard…?

H40MA: I feel like I do but I'm actually not sure now. I think we're paying something like £60 a month gas and a bit less on electricity, £45 something like that. But then again you see, we get all our energy from NPower and they do these tariff things where you get 10% off for this and quarterly direct debits and blah-blah-blah.

H42MA: Our meter says we have Economy 7, but we've got no idea if we have.

H42FA: We're assuming that we have. We could just be doing it for false pretences.

H42MA: I don't think the gas and electricity people help us though, do they? They don't send you a bill anymore. They just tell you how much you need to pay a month and then they tell you've either paid too much or you've paid too little.

H42FA: It's difficult to gauge because you always end up in credit over the summer months and then in deficit over the winter months. You sort of use the credit that you've built up pretty rapidly over the winter.

In some respects this confusion over energy and tariffs could be seen to be reducing the amount of energy consumed by keeping the cost higher than it could be, but in reality it inhibits the occupants from really engaging with subject of energy use. If they cannot understand the implications of what they are doing on their energy consumption they are unable to make informed decisions about how they could reduce their use. There is a chronic lack of feedback about the whole process which prevents the consumer from making the changes in their every day practices. This especially applies to the direct debit system of payment operated by many energy providers, which disconnects actual energy use from the billing cycle through it's annual cycle.

H18MA: Hmm. It's like, for example, if you get a telephone bill you get the area code and the telephone number, and how many minutes it's been called and what that cost. Now in theory energy companies should be able to do that for gas and electricity and in a way even if it was just the time of day and the length of period, we could work it out knowing our washing machine takes one hour and 59 minutes for a particular load and so we would know how much that would cost.

There is a need to directly connect actual energy use with energy tariffs through a mechanism of disaggregated, predictive feedback. Unless occupants are able understand the impact of their different behaviours on the actual cost in an accurate and meaningful way, it is unlikely that they can effect responsible change. Such as system should also be integrated with the various tariffs available to enable occupants to see which options better fit their actual, or intended, energy use. As energy demand shift allows power to be generated more efficiently an increased uptake of this,

including appropriate energy consuming practices, should cause a net reduction in CO2 at the point of production, even if not in the individual home.

7.6 Convenience Baseline

Closely related to the Comfort Baseline explained above, there was a strong sense that participants would not voluntarily go beyond a point at which they would make their live untenably difficult. This becomes particularly pressing when parents have younger children who generally require a lot of time anyway. Most commonly mentioned were labour saving devices like dishwashers, washing machines, and tumble dryers which spare a huge amount of time and effort. Interestingly there was often a fear that design interventions would target these appliances, particularly from mothers of families (who in our sample did the majority of domestic tasks). This implies that while they know these appliances consume a lot of energy, they find them to be so integral to their lives that they couldn't give them up.

> **I:** Would you say there's a baseline of kind of comfort and convenience that you just won't go below that.
>
> **H10MA:** Yes, yeah. Well not would go below, but just don't go below for convenience.
>
> **H10FA:** Because our bills aren't that extortionate… They're high enough, but because we know that we're still below average, then there is a little bit of leeway in there and, like I say, it's comfort and convenience over cost.
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>
> **H42MA:** I mean for me I suppose the big thing is it would have to fit in around the family and it has to be practical from that point of view really. But yeah, I think it'd be an easy thing to do as long as I was kind of sign-posted I suppose because I don't have a lot of free time to investigate things thoroughly or research things as thoroughly as I would have done 5 years ago.
>
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>
> **H43FA:** We don't. I put the tumble dryer on all the time because it's convenient and because I'm willing to spend the money on the tumble dryer because I've got a clean load that I don't really need to

iron, but they're dry and I can pull them out. Yeah, I'm aware it uses a lot of electricity and it's not environmentally very sound, but I want dry clothes and I want to be able to fold them up and put them away. So yeah, I'm aware of it, but I don't alter massively. No, not massively.

H43FA: But I mean things like… Because I have an electric shower every day and maybe using the shower that runs off the boiler would be more economical. That sort of thing yes, I could do [xxxx].. But if you started saying "Don't use your tumble dryer and put 60 watt light bulbs in that give you a dingy light," then I would just say "Actually, no."

H45FA: Well, there are certain things that I'd have to compromise on. For example, would I want to wash my clothes in a washing machine or would I want to wash up my dishes? So I'd compromise and say "Okay, I'm never going to give up my washing machine because I'm not going to go to the laundrette or wash clothes by hand." That is a huge labour saving. However, I could give up my dishwasher. I could because I quite like washing up and I think its part of what we'd do. We'd wash up, dry up and put away.

Any design approach must recognise that there are aspects of energy use which will be highly resistant to change. These are generally the labour and time saving devices which are integral to modern lifestyle i.e. in many families both parents work full time and would struggle to complete all domestic tasks manually. Furthermore, to heavily target these appliances could cause some participants to disengage from the process of energy consumption reduction.

7.7 Contextual Barriers

Though not necessarily the focus of the interviews, several of the participants spoke of contextual barriers in the home which hindered them from using less energy. This is of particular note as it is likely that all homes have unique features which affect the energy efficiency of appliance use or prevent occupants from taking greater action. Some of these are fairly widespread, such as DM suites being stuck on standby because of inaccessible plugs. Others are perhaps less common, through probably far from unique, like thermostats situated near heat sources or poor wireless signals.

H38FA: Standby buttons on our upstairs telly because there's no… Other than switching it off at the plug, which we can't get to because there's something in front of it, there's no way of switching it off, so that stays on all the time, whereas, you see, this TV we can switch it off at the plug so the standby goes off… and the downstairs TV. But we've got one in our bedroom and the standby light is on all the time.

H08FA: Me probably because I work from home. So on the days that I'm at home in the winter I would have the heating on, whereas if we're out for the day… Because you're out at school, dad's out at work and if I'm in Manchester, then the heating's off for the day, whereas if I'm here, then the heating's on for the day. So it's definitely I think..

H08MA: And we heat the whole house, don't we?

H08FA: Yeah, for me to work in the office.

H08MA: And that's because it's not convenient to do it any other way really. We have thermostats on the radiators, but we never really seem to get anything sensible out of them.

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I: Do you mainly have paper bills you look at?

H18FA: Yeah.

I: You don't do it on-line to check anything?

H18FA: No, partly – and this is going to sound really silly – but it's one of these things I haven't got time to sort out is that at the moment with our laptop we can only access the internet on that side of the house, which means I either do it… Normally the laptop's up in our room or in the lounge, but the children are still at the age where the laptop's very interesting, so I tend not to go on the computer when they’re here. I suppose if I could have it on the kitchen unit then maybe I would, but…

H18MA: I try to turn that lamp off sometimes in the hallway because it’s directly below the thermostat.

It is difficult to anticipate the existence of the myriad contextual features which would constrain RECBs, but one commonality they seem to share is that they are tied to a physical place, the characteristics of which make them inefficient. One approach is to release these features from the context is by introducing remote control in some form. This would free the occupant of the constraint without having to engaging in costly rewiring or disruptive moving around.

In addition, it may better to try and design any interventions which require human interaction to be either portable or situated in a place with easy access i.e. fridge doors, lounge walls etc. This would free such intervention from these issues and make use easier and more likely.

7.8 Forgetfulness

A commonly mentioned barrier to RECBs was a universal human issue; forgetfulness. While obviously this is something that will always be an issue in any activity, what it means for energy consumption is that even if people are keen to reduce their usage they may end up not. People often spoke about forgetting to turn off lights, but this is presumably because lights are very noticeable when found on and it is likely that many other appliances are often left running too. This is not limited to switching-off practices; it is also common for people to forget to do things like laundry in time and then end up using the tumble dryer.

I: Do you switch off your computers when you go to sleep or do you leave them on standby?

H01FA: I forget mine sometimes.

H01FAc1: I leave mine plugged in though and the box gets really hot.

H01MA: But there's quite a lot of computers actually carry on taking power even though they're switched off.

H18FA: When you've been sitting here with the children for an hour doing something at the table you think "Oh, the TV's still on in the other room!" I'm always forgetting.

H42MA: Yeah, the chaos probably comes a lot from me. I'm the sort of person who starts about 17 different things at the same time and then doesn't really finish them. You say that I'm a bit scatty in terms of my… If this is about energy use – I leave lights on, I leave stuff on.

H42FA: You're a bit forgetful.

H42MA: A bit forgetful, but hopefully not in a bad way. I don't mean to forget things. I don't know really.

H05MA: There's two more to go and then we will have done that. So certainly in terms of lights and things like that, turning things off. We're not brilliant at it.

I: What do you find difficult?

H05FAc1: Remembering to turn them off.

H05MA Remembering, most people, isn't it?

I: Do you know how much energy you use?

H05FAC1: We've got one of those meter things, haven't we?

H05MA We have got one of those meters, but somebody unplugged it and I've forgotten to put it back in.

This has two main impacts on intervention design; firstly it seems useful to incorporate a reminder system to help people remember to do tasks in the most efficient manner; secondly the design itself can aim to minimise forgetfulness through a strong visual presence or prominent placement. Both of these approaches aim to build user habits through repetition, a tricky but fruitful proposition.

There is another approach which seeks to reduce the mental load on the user and automates energy efficient tasks. This can be extremely useful as long as the settings are aligned with the user's actual needs.

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> **H08MA:** Yeah, it's got a much more sophisticated timer.
>
> **H08FA:** …and then as soon as it drops to below 7 degrees the boiler kicks in, which is great because that's exactly what you want to happen, whereas this boiler that we've got here it's either on or off. Okay, you can control the temperature but, you know, when you go away for the weekend, which we do a lot, sometimes you forget to switch the boiler off. I mean I normally try to switch the hot water and the boiler off, but sometimes you forget when you're rushing. Or if it's winter you can't switch it off because of the pipes, whereas I think the holiday mode is… you know, that's quite a good idea.

7.9 Individual Agency

The role of the individual in addressing what are global problems and the potential impact of their actions on those problems were real concerns of many participants. There was often a sense that other people were not behaving responsibly or in an energy conscious manner and that any action taken by the individual, at the cost of considerable effort, was in effect meaningless compared the wasteful consumption of millions. This was expressed to varying degrees by most of the participants, often while acknowledging that they would make an effort regardless. In many senses it was a conflict between a rational ideological stance to behave pro-environmentally and normative awareness that most other people do not. This is compounded by the perception that big industry is a far bigger environmental culprit that the individual in a domestic setting.

I: So do you believe that your behaviour and lifestyles are really contributing to these issues and do you think about those things when you go around your daily routines?

H01FA: There are times when I put the tumble drier on and think "I shouldn't be doing this. I should hang it out on the washing line, but there's a chance of showers and I've got to go out and I need it dry, so I'm going to put it in the tumble drier."

H01MA: I suppose sometimes you just feel like powerless – that you could do your bit and you almost feel like it won't make any difference.

H01FAc1: And what's the point because no one else is bothering.

H01MA: Well, you know lots of people, even up and down this street which is quite a nice area, and they just wouldn't bother making an effort.

I: So what you're saying… Do you feel that your behaviour, your daily routines play a major role or not really in these sort of issues?

H30FA: I don't think they play too much of a big role. I mean the whole way we live is bonkers, isn't it? Kind of going out and buying new televisions and new this and new that all the time. It's kind of a bit of a crazy world, but that's the way we're all living, so as one tiny, little person does that make a difference? But obviously put together I'm sure it does. Did I answer the question?

I: Yeah, yeah. So we should be doing more. Is that what you feel in general or are you a bit sceptical?

H30FA: A little bit sceptical. I mean we do all this recycling of bottles and things and then they go to landfill anyway, you know.

I: So am I right to think that perhaps it does worry you in terms of your bills, but it's not like a big concern?

H30FA: No, I wouldn't say that. It is a concern. I'm not uninterested. I'm just rather a little sceptical, but just feel… it's perhaps not the right word to use, but kind of rather impotent to change it or to know / to be confident that what we're trying to change is the right thing.

Any intervention strategy can seek to address this conflict through two different channels. Firstly the impact of domestic energy use should be shown as a proportion of national consumption, and the potential savings that can be achieved through RECBs should be shown to validate such action on a broader stage. These are significant numbers, and were not commonly known among participants.

Secondly, there is a need to show that others are also taking energy saving action (regardless if their motivation is financial or environmental) through the form of relevant social proof. This could be achieved through testimonials or social networking platforms or even by making it physically visible through the form of window and bumper stickers.

7.10 Lack of Information

One of the greatest barriers to RECBs was a lack of concrete and credible information about energy consumption and environmental impact. The sample were, in general, probably more environmentally aware than average, however they were still confused about many different specific aspects of energy use. This seriously inhibited many from taking positive action and it provided an excuse not to make changes.

The most pressing concern in this area was what was the actual amount of energy (and thus financial cost) used by different appliances at different settings. In addition there was a desire to be able to make comparisons between different appliances or settings.

H01MA: I suppose the interesting thing we don't know is what it costs us to have an individual device on. So if we've got the television on how much electricity is that using for an hour? Or I put some chips in the oven, which we know from our meter takes up a lot… It's an electric fan oven and we know that takes… and it's quite old. I suppose it's as old as this house, isn't it? So that's quite old and it's probably very inefficient.

H01FA: Probably.

H01MA: Are those chips really, really expensive? And there's some things… I know that when Graham came round he looked at the power supply for the fish tank. That's the only one I could buy, but it gets very, very hot which means it's inefficient. So should that be changed?

I: And which processes do you think use most of the energy at home?

H42FA: The washer is on pretty much constantly, so I think that probably uses a fair bit of energy; and the TV I suppose. I don't know how much… I've no idea how much each of the appliances how much energy they do use, so that in itself would be an interesting sort of…

H42MA: I would have thought the kettle and we tend to drink quite a lot of tea. Yeah, I would have thought that uses quite a bit. I don't know how much stuff uses either.

H42FA: I kind of don't have a problem with all the boring sort of practical stuff and I think it'd be really easy to make changes, but it's just knowing what changes to make or how to make the changes. I mean for me I suppose the big thing is it would have to fit in around the family and it has to be practical from that point of view really. But yeah, I think it'd be an easy thing to do as long as I was kind of sign-posted I suppose because I don't have a lot of free time to investigate things thoroughly or research things as thoroughly as I would have done 5 years ago.

H45FA: Yeah, but we haven't done any research. I wouldn't say we were informed choosers here. We're actually probably grasping in the dark because actually if you were doing an informed choice nobody would ever put those [12 halogen down lighters], but they look so much nicer than having a strip of four spots – and we tried all that and you end up with pools of darkness. So when we had the kitchen done 2 years ago that was the choice we made, but energy-wise it's not a good choice. It's difficult, isn't it? I think we need to have more information as well. Perhaps we need to spend more time researching.

H45MA: I suppose it's hearing messages about global warming and things like that and it's translating that into practical activities, you know. I guess one of the things that would help us to understand how to save energy is to have information very easily accessible to us to tell us what we're using and how we're using it and how we can improve and I think if that's difficult to find, then it disincentivises any activity. We were watching that thing with Attenborough, that shrinking of the Arctic Ice and the effects that could have long-term which is, you know, very interesting and then you think "Let's go boil the kettle and have a cup of tea."

H45FA: Yeah. Well it's that fine line between boiling a kettle of water to fill a hot-water bottle to put upstairs or to switch on an electric blanket. Switching an electric blanket on for 10 minutes… it's not even 10 minutes, but, you know…

There is an expressed need to provide occupants with easily accessible accurate information about domestic energy consumption. This information should deal in comparable understandable metrics that are relevant to the desired behaviour. Without such information it is unlikely that users will take positive action, but neither will its provision guarantee any behaviour change. Thus such information should be situated in the behaviour, by its inclusion at the point of interaction. This could a physical form, such as a sticker on an appliance, or it could be supplied through a digital control platform. However, the gathering of this information is a bigger technical challenge and requires numerous sensors or user data input. Appliance harmonics monitoring is a more promising route for this data collection but is not yet widely available.

8 Energy Reduction Interventions: Experienced and Desired

8.1 Introduction

Many participants were aware and interested in energy saving technologies. Some had already experienced energy monitors and others had ideas of their own as to the nature of design interventions they would like to see. Both of these are extremely relevant to the design process as they map out the successes and failures of existing interventions, as well as lighting the path for future developments.

8.2 Previously Experienced

8.2.1 Energy Monitors: Short term effect.

A number of households had already used plug-in type electricity monitors that they had received from their energy providers. Participants had fairly mixed reviews of these and report and number of aspects that are of note.

All of the houses which had monitor reported using extensively when they first received it and trying to go around the house turning appliances off. Several referred to this period as being quite stressful as they were trying to find out what specifically was using energy based on an aggregated feedback. However all the respondents had ceased to use the devices after a while, either because they felt they had already made the changes they could or because the device was unplugged at some point and never plugged back in.

> **H05FAC1:** We've got one of those meter things, haven't we?
>
> **H05MA** We have got one of those meters, but somebody unplugged it and I've forgotten to put it back in.
>
> **H05FC2:** That was Mary.
>
> **H05MA** We've got a little energy monitor that we plug in around there. It's not plugged in at the moment, but that will tell us what we're using at any one time. It shoots up when you put…

H05FA:…anything with an element in it really.

H05MA: Elements, yeah.

I: And did it change your behaviour when you got that in? Were you trying to keep an eye on things?

H05FA: Yeah, it did me. It was dreadful.

H05FAC1: It was good for fitness because I kept moving backwards and forwards to check it.

I: So does it mean you had less tea or whatever you….

H05MA: I think what it is, it changed our behaviour initially because you were constantly keeping an eye on it and then after 2 or 3 weeks for some reason it got buried behind a fruit bowl and if it wasn't there showing you, you just took your eye off it and forgot about it. But then it got unplugged and we didn't even realise it had been unplugged for a fortnight. [laughter]. So I think we'd probably need something that was sort of that size on a wall **[indicating clock size].**

There were several problems mentioned with design of the standard type monitors, some participants thought they were too prone being unplugged and forgotten about, others had issues the way the information was presented and the unit and metrics use. One exception was the Wattson, an ambient energy monitor, which was felt to be very intuitive by its owners particularly the children.

H40fc1: We used to have this thing Daddy set up and it told us how much energy we were using.

H40MA: It was a Wattson, if you know what that is, but it broke.

I: And how did you like that, or did you like that at all?

H40MA: I thought it was okay actually. In some ways it's one of the better indicators of use where a lot of them tend to be a bit confusing and obfuscated. We have another one actually that came free.

I: From NPower is it or…?

H40MA: Yeah , it's a Green Energy Options one, if you know who they are.

I: I don't actually know them, no.

H40MA: They supply most of the free monitors in the UK. I think they supply to 5 of the big 6. … but it's a bit of a travesty in the way that the government has operated. Their trying to be energy conscious plans has meant that a lot of households have ended up with energy monitors that are probably less than useful, never mind ideal. I can show you the one over there, but it was so… I mean I'm relatively competent with these sorts of things and even I couldn't get it to work in a state that I could understand what it was saying to me.

I: And do you have any interest in this new monitor?

H40FA: No because I haven't seen it working really, so no

. **I:** What about the Wattson, did you…?

H40FA: Yeah, that was quite interesting. When it went up I was like "Oh, what's happened to make it go up? What's running?" It did question….

H40MA: That's the useful part of the Wattson. It's simple, but it's all you need really if you're conscious of energy use.

A problem with all energy monitors is that they just provide information about what is being consumed without situating this information in family life. After a while people stopped paying attention to them as there was not that could be done about a lot of the energy being used, i.e. if someone is having a shower it is going to use energy, but these monitors don't provided any context for what is happening or scope for realistic action. In this sense they are only really useful for spotting appliances that have be left on while not in use, a feature which appeared to grow tiresome after a while.

> **H43FA:** Do you know what? Npower sent us a meter to put on the electric meter so I could see how much electricity we were using and I think I put it on there for 2 months and all we saw – that every time I got in the shower it went up and every time that I used the tumble drier it went up, so I just thought "I don't want to look at it. I don't want to look at it anymore."
>
> --
>
> **I:** So you've got a monitor then?
>
> **H01FA:** It's not on at the moment.
>
> **H01MA:** Well we had one and watched it, then you see the patterns and you kind of learnt the lesson, so you don't need to keep looking at it.

There is a need for such displays to be more durably situated in the home in a way that socket based monitors are not. This could be by locking the monitors in position so they aren't unplugged and forgotten about, or by designing such a display to take a more prominent position like a wall clock on a fridge door. It seems more promising though for such energy portals to piggyback existing hardware such as smart phones, PCs or TVs as these are already situated in family life and have more than sufficient technical capabilities. The appeal of the Wattson's ambient display as a medium of energy monitoring is also noteworthy, live energy data loses interest after a short period, but ambient feed back is more durable in that respect.

It is interesting that these monitors created initial excitement and interest from participants, but that this soon fell away as there was not a huge amount that they felt they could , or were prepared to, do. It is important for any monitoring design intervention to capitalise on this initial interest and use it to generate RECBs. One way it could do this is be contextualising the energy use into more meaning and comparative terms and engaging the occupants in target setting or commitment strategies. The

primary issue is that of assigning energy use to actual behaviours and educating occupant as to lower energy alternatives and their financial or environmental benefits. For example, instead of showing that a 15 minute electric shower uses 3.5kWh, such devices could show that by reducing shower time to 7 minutes would save £15 pounds a year. However information alone is unlikely to affect prolonged behaviour without continuous prompting, ideally before or during such behaviours

8.2.2 Meaningful information and visualisations.

One participant spoke of an energy visualisation that she had seen of TV which showed people cycling to power a houses electricity needs. The visualisation had a marked effect on her and she had subsequently changed her behaviour around kettle use. This is a very good example of the transformative power of meaningful information and how for most people energy is an arbitrary concept until linked to something tangible.

> **H40FA:** One thing that struck a chord with me was we saw this programme on telly about energy – I can't remember what it was – where they were cycling to provide energy.
>
> **H40MA:** Oh Bang Goes the Theory.
>
> **H40FA:** So basically they had a family in a household with a load of cyclists in the background and I can't remember how many there were, but…
>
> **H40MA:** So it was a house and all of the electricity supplied to the house was generated by this hangar full of cyclists with generators on their bike. So if they turned on the television and turned on the cooker, because they baked a…
>
> **H40FA:** They had to have about 30 cyclists sort of cycling away to provide the energy.
>
> **H40MA:** It was a fascinating visualisation of energy.

H40FA: It was really good.

I: And was it because of that that it showed you actually how much…?

H40FA: Yeah, it made me realise how much energy you use. I am a bit more conscious as well. And one of the things that came from it, which was very small but everything helps I suppose, is when you boil the kettle they were sort of saying … I think they go through top tips of sort of saving energy and one of them was like don't boil the kettle, walk away and do something else and then come back and re-boil it. And I think they were showing that and had about 5 more cyclists on the re-boil, you know, and now I never do that, which was one of my bad habits and now I'm very conscious of it. So I always like hang around and make sure I make my cuppa without getting distracted

Design should pay attention to expressing the vast amount of energy used in modern homes though intuitive and visual means. Such an approach, if done successfully, can break through the indifference most people feel about energy and link their behaviour to something they can relate to. It is important to frame this information in such a way that it does not make the situation seem hopeless and so the comparative metrics must be seen to be achievable by users.

8.2.3 Prepaid units, commodified energy

Another participant identified the unlimited and invisible nature of electricity provision as major contributing factor to energy use. She expressed a preference for athe prepaid system they had had before as it commodified the amount of energy they were using and allowed them to manage their use as it happened rather than being presented with a surprisingly large and unaffordable bill three months later.

H41FA: Yeah, but I've said that before to you. I would love it if we had a gas meter and electric meter because that way, to me, you're paying for it as you're using it rather than…

H41MA: It used to be 50p years ago.

H41FAc2: How long did 50p last?

H41FA: A long while, weren't it, really then. There were times when we'd sit watching the television – bearing in mind in the winter at night watching the television – and if you hadn't kept an eye on it and it went and you had to put another
50p in, well all the electric went off because the bob had run out, so you had to get a torch to find where to put the money

There could be scope to provide occupants with an analogue of the prepaid meter by combining a target setting approach with digital units of credit. Such a system could replicate the interaction by requiring the user to top up their "meter" digitally or risk have their power stop though a linked hardware switch. While such an approach is rather extreme, it may well prove attractive to those under financial pressure, and unlike a physical pre-pay meter it would not require high installation fees and a punitive tariff.

8.2.4 Smart technology

There was some evidence of "smart" energy conscious technology appearing in people's houses, one family had a TV which would switch itself off after 3 hours. Interestingly they seemed quite happy with this delegation of control, and it opens the doors to more automated technology appearing the home.

> **H08fc1:** And one of the TV sets turns off by itself.
>
> **H08MA:** Oh, the TV turns off by itself, doesn't it, if we don't nudge it.
>
> **H08fc1:** If you've been watching it for more than 3 hours.
>
> **I:** Does it switch off after 3 hours?
>
> **H08MA:** Is it 3 hours, is it? You would know because you watch telly for 3 hours non-stop quite often.
>
> **H08fc1:** Something like that. I think it's something like that. 3 or 4 hours.
>
> **I:** And does it let you switch it back?
>
> **H08fc1:** Yeah, you just press a button and it's on.

8.3 Future Interventions Desired

Participants raised a number of issues regarding what they would need to make energy consumption relevant and what they would like to see incorporated into future energy interventions. These ranged from technical specifications to meaning making to desired government policies. These are fascinating in many respects and many are highly relevant to future design work, but equally none should be followed blindly without future design evaluation.

8.3.1 *Meaning making*

It was felt that future interventions should be able to clearly express the objective in making behavioural changes, and that information alone would not be sufficient to motivate change. This refers to the how and the why of RECBs and is crucial to the engagement of users.

> **H37MA:** Yeah, I think we'd all need to understand what the objective of doing it … what was the reward almost, especially with the girls. I think again it goes back to the data. If I saw that everything was sort of average and then this one thing was spiking I'd be going back to my irresponsibilities again and thinking "Well, we're pretty good over here…"

8.3.2 *Itemised costs and energy consumption break downs*

There was widespread interest in being able to see what a given appliance was going to cost and how much energy would be use. Participants were particularly keen to able to compare what each setting would cost them so as to be able to make an informed decision on how to reduce consumption.

> **H01MA:** I suppose the interesting thing we don't know is what it costs us to have an individual device on. So if we've got the television on how much electricity is that using for an hour? Or I put some chips in the oven, which we know from our meter takes up a lot… It's an electric fan oven and we know that takes… and it's quite old. I suppose it's as old as this house, isn't it? So that's quite old and it's probably very inefficient.
>
> **H01FA:** Probably.
>
> **H01MA:** Are those chips really, really expensive? And there's some things… I know that when Graham came round he looked at the power supply for the fish tank. That's the only

one I could buy, but it gets very, very hot which means it's inefficient. So should that be
changed?

H23MA: No, it's just pound notes , that's what it's all about. I know on price comparison sites you have to put your usage down, don't you? I'd have to go and look at the bills. [cross talking]. I wouldn't have a clue what we use to be honest with you. Yes, we just pay by direct debit and it went up from £35 to £80 and it's dropped down to £75 now, hasn't it? But yeah, that made me look and think "Crikey!"

H23FA: Yeah and you think "What have I got to do to reduce it and how can I do that?"

I: And is that a bit of an issue being able to tie those pounds and pence back to specific items or specific tasks?

H23MA: It'd be useful.

H23FA: Yeah, it would actually.

H18FA: And I think, going back to what I was saying about the bills and looking at changing suppliers and not really understanding what it is – you know, if that was made simple so you could look at your dishwasher manual and say "Right, these are the five programmes. This is how much they use. This is how much kilowatt of energy it'd cost me. This is how much it costs me to put my dishwasher on," even something as simple as that I'm sure would make a big difference.

H18MA: Hmm. It's like, for example, if you get a telephone bill you get the area code and the telephone number… [*cross talking and laughter*].. and how many minutes it's been called and what that cost. Now in theory energy companies should be able to do that for gas and electricity and in a way even if it was just the time of day and the length of period, we could work it out knowing our washing machine takes one hour and 59 minutes for a particular load and so we would know how much that would cost.

This points towards a digital consumption calculator featuring a database of appliances and energy consumption. While this would be very useful, the logistics of accurately collating the energy consumption of the many thousands of different models appliances makes it unrealistic. More likely alternatives would be approximated data bases (similar to the DECC appliance consumption data base), or consumption data gained thorough localised device monitoring. The obvious platform for such a tool would web based and accessible through smart phones or PCs.

8.3.3 Realistic Reductions

One of the key resources desires in future interventions was the provision realistic and attainable reductions. This is particularly relevant when occupants are already trying to minimise their use and don't necessarily see further opportunities for reductions.

H18FA: At least. But I think, you know, a lot of the major decisions seem unavoidable, but there must be other sort of more discreet things that we could be doing that would make a difference. I think that's what we're interested to know.

I: To see what the easy wins are then.

H18FA: Yeah. Like, you know, we have to have the lights on and we have to do the laundry. That's the unavoidable, you know. I remember Linda saying something about that in their house they just wash their hands in cold water, but I can't really be washing the children in cold water. [*laughter*]. Do you know what I mean – there's things that you kind of think while they're little, you know, they do get cold easily and that kind of thing, so we can't just all put on extra jumpers on Yeah.

8.3.4 Appropriate Situated Feedback

As shown previously feedback devices often have limited effects because they are situated outside of the energy consuming activity and don't offer satisfactory alternatives it. One participant got to the nub of this by proposing a feedback device by the door which would alert you when energy was being needlessly used as you left.

H08MA: I always thought it'd be good to have a gadget by the front door that tells you when you've left things on. You know, like people always worry that they've left their hair straighteners on, for example, and that sort of thing. So that's not so much about reducing energy and more about setting the house on fire, but it would serve a dual purpose I think, you know, if there is a way to sort of see just as you were leaving that it was drawing current from somewhere or other and you'd left devices on. That I think would be something that would prompt me to do something different – usually race round the house switching it all off.

8.3.5 Remote Control and Smart Controllers

Several of the smartphone owners amongst the participants had grasped how the broad range of capabilities of their phones (i.e. wireless connectivity, geo-location, portability) could be harnessed as a feedback portal and smart remote control for many energy consuming appliances. Given the predicted rise in smart phone ownership, this seems to be a viable option which negates the need for separate expensive display device.

H10MA: Well, I mean one of the interesting things would be what you do in terms of like smart phone applications and things like that because if I've got…. For example, if I'm sitting watching TV I can always flick and do stuff, checking abstracts and whatnot.

I: So you find that you're often… it becomes that kind of dual processing – that you're doing something but you're not quite there because you're also doing something else.

H10MA: But if you were going to do stuff like smart plugs that talk to this (SMART PHONE) so that you can see what's going on and you can switch things on and off, then I'll be well into that.

H42MA: Yeah, very recently. So yeah, but it was very cold when we came back on Sunday. I want them to invent that kind of, you know, phone your heating. They have invented it, but…

H42FA: Well, my mum phoned and she said "Do you want me to go round and put the heating on?"

H42MA: Yeah. You see, why didn't you say yes? [*laughter*].

H42FA: Well I was like "No because we're not there and it's a waste of money."

H40MA: No, all of it, the water and the central heating. But for instance if I were out and Lorraine was at work and she wasn't coming back until late, the heating would still come on at 4 o'clock or whatever which it needn't do. If you could walk out of the house and say I'm out… If the heating system control understood people and what they were doing and where they were and you could clock in and out, then it could probably more intelligently work out whether it should be on or not at a certain time whereas it's a very, very simple heating control.

Smart phones and other portable devices offer an extremely powerful platform to any design intervention. The y are in many senses the most intimate piece of ITC technology that people interact with, but they also connect user to other people and things in the wider world. They are rapidly becoming the default platform for many services and organisations, which is leading to an increase expectancy of the "iPhonisation" of all services. While still only owned by a minority of the population, they are predicted to quickly gain the same level of saturation that tradition mobile phones have.

The smartphones' strengths lie not just in their technical capabilities, but in the nature of interaction they inspire. They remove physical contextual barriers, by being on the owner's person and allowing remote control and communication. This would allow energy related behaviour to take place both physically and temporally outside of busy family household life.

Their potential roles in energy demand reduction are varied; at the most basic level they could provide access to relevant information on energy efficacy, but these devices also have the capability to remotely interface with other hardware to relay energy usage data and to allow automated remote control of appliances. These later capabilities demand the development of new hardware devices which can communicate and control between appliances and smart phones.

Appendix G: Ethics Document

ETHICAL ADVISORY COMMITTEE

Loughborough University

RESEARCH PROPOSAL
FOR HUMAN BIOLOGICAL OR PSYCHOLOGICAL
AND SOCIOLOGICAL INVESTIGATIONS

This application should be completed after reading the University Code of Practice on Investigations Involving Human Participants (found at http://www.lboro.ac.uk/admin/committees/ethical/ind-cophp.htm).

1. Project Title

LEEDR: Low Effort Energy Demand Reduction.

2. Brief lay summary of the proposal for the benefit of non-expert members of the Committee. *This should include the scientific reasons for the research, the background to it and the why the area is important.*

The aim of the LEEDR project is to understand the householder and their practice as it relates to energy consumption and to digital media use in the home in order to develop and test the effectiveness of 'low effort' energy demand reduction intervention measures:

The need for the reduction of the demand for energy is a global issue and the UK Government has committed the UK to an 80% CO_2 reduction target for 2050[1]. Of the total demand, energy use in dwellings in 2008 accounted for nearly 30% of energy use in the UK[2]. At present, metered energy data currently only translates total domestic electrical loads into a time averaged kWh data, plotted against time, explaining nothing about where or how the energy is used, or why.

There have been many energy consumption studies over the last few decades, although intervention studies in the UK have been limited[3]. The focus of these studies has been on the end use of energy but without connection to energy related to domestic practice. As social science studies undertaken in Nordic countries have emphasised[4,5], understanding this practice and how householders interface with technology and energy information is key to the development of effective strategies and interventions that can be adopted to bring about significant reductions in energy demand. Understanding how householders' digital media practices and aspirations can be harnessed to create user-led 'low effort' interventions to enable strategies for energy demand

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[1] Climate Change Act (2008) URL: www.opsi.gov.uk/acts/acts2008/pdf/ukpga_20080027_en.pdf. Assessed 21/12/09

[2] Chapter 1: Energy. Digest of United Kingdom energy statistics (2009), URL: www.decc.gov.uk. Assessed 11/12/09.

[3] M. Martiskainen 'Household energy consumption and behavioural change – the UK perspective' Chapter 4 in *Proceedings: Referred Sessions I-II. Sustainable Consumption and Production*. www.score-network.org/files//24116_CF2_session_1-2.pdf, accessed 14th December 2009

[4] K. Gram-Hanssen, Kirsten 'Heat comfort and practice theory: Understanding everyday routines of energy consumption' Chapter 1 in *Proceedings: Referred Sessions I-II. Sustainable Consumption and Production*. www.score-network.org/files//24116_CF2_session_1-2.pdf, accessed 14th December 2009.

[5] A. Henning, (2006) 'Can qualitative methods support the development of more flexible and energy saving thermal comfort?' In *proceedings for the international conference 'Comfort and energy use in buildings - getting them right'*. http://nceub.org.uk/uploads/Henning.pdf, accessed 14th December 2009

reduction to be built into everyday media practices that are already embedded in the lives of, familiar to or aspired to by consumers.

3. Details of responsible investigator (supervisor in case of student projects)

The responsibility will be shared amongst the investigators according to the university lines of departmental responsibility and specifc project responsibilities.

Name	Experience	Department	Email
Richard Buswell Principle Investigator	Senior Lecturer in Building Services Engineering	Department of Civil and Building Engineering	R.A.Buswell@lboro.ac.uk
Roy Kalawsky Co-Investigator	Professor of Human-Computer Integration & Systems Engineering:	Department of Electronic and Electrical Engineering	r.s.kalawsky@lboro.ac.uk
Tracy Bhamra Co-Investigator	Professor of Sustainable Design,	Loughborough Design School	t.bhamra@lboro.ac.uk
Murray Thomson Co-Investigator	Senior Lecturer in Electrical Networks and Systems	Department of Electronic and Electrical Engineering	m.thomson@lboro.ac.uk
Sarah Pink Co-Investigator	Professor of Social Sciences	Department of Social Sciences	s.pink@lboro.ac.uk
Shuang-Hua Yang Co-Investigator	Professor of Networks and Control	Department of Computer Science	S.H.Yang@lboro.ac.uk
Val Mitchell Co-Investigator	Research Fellow in the Ergonomics and Safety Research Institute (ESRI)	Loughborough Design School	v.a.mitchell@lboro.ac.uk

4. Names, experience, department and email addresses of additional investigators

Name	Experience	Department	Email
Lynda Webb	Senior Researcher	Department of Civil and Building Engineering	l.h.webb@lboro.ac.uk
Ian Richardson	Senior Researcher	Department of Electronic and Electrical Engineering (CREST),	I.W.Richardson@lboro.ac.uk
Xin Lu	Senior Researcher	Department of Computer Science	X.Lu2@lboro.ac.uk

John O'Brien	Senior Researcher	Department of Electronic and Electrical Engineering	J.T.OBrien@lboro.ac.uk
Carolina Escobar-Tello	Senior Researcher	Loughborough Design School	M.C.Escobar-Tello@lboro.ac.uk
To be appointed	Researcher	Department of Social Sciences	
Graham Jackson	Research Student	Department of Civil and Building Engineering	g.v.jackson@lboro.ac.uk
Roxana Morosanu	Research Student	Department of Social Sciences	R.Morosanu@lboro.ac.uk
Marcus Hanratty	Research Student	Loughborough Design School	m.hanratty@lboro.ac.uk
To be appointed	Research Student	Systems Engineering	

5. Proposed start and finish date and duration of project

Start date: October 2010 Finish date: May 2014 Duration: 3years 7months

Start date for data-collection: Mid February 2011

NB. Data collection should not commence before EAC approval is granted.

6. Location(s) of project

All Householders will be recruited within an 10mile radius of Loughborough University

7. Reasons for undertaking the study (eg contract, student research)

EPSRC grant funded through the Transforming Energy Demand through Digital Innovation (TEDDI) initiative.

8. Do any of the investigators stand to gain from a particular conclusion of the research project?

No

9a. Is the project being sponsored?Yes ☐**No** ☒

If Yes, please state source of funds including contact name and address

9b. Is the project covered by the sponsors insurance?Yes ☐**No** ☐

If **No**, please confirm details of alternative cover (eg University cover).

10. Aims and objectives of project

The aim of the LEEDR project is to understand the householder and their practice as it relates to energy consumption and to digital media use inside and outside of the home in order to develop and test the effectiveness of 'low effort' energy demand reduction intervention measures. This will be achieved through the completion of a number of objectives:-

- Detailed analysis of current domestic energy related practice, identifying opportunities for reducing energy consumption combined with an investigation into the use of digital media inside and outside of the home to ascertain how the use of technology can be harnessed and developed to support user-led energy demand reduction.

- Expert-based forecasting to determine as accurately as possible, how these practices might be expected to change over a 40 year time horizon, in the context of the planned refurbishment of the existing UK domestic building stock and the changing technology and economics of energy resource and supply.

- Iterative innovation and development processes involving householders, energy providers and UK business to fully explore householder requirements, desires and motivating factors, the constraints of energy provision and the reality of business, to establish the 'ground rules' for the design of energy demand reduction intervention measures that use ICT as an enabler.

- Designing an energy demand reduction intervention approach (or approaches) that offers maximum impact potential and minimum risk by fulfilling the following criteria: Tackles at least one of the worst offending energy related practice in the home; is appealing to the householder; will grow in popularity and continue to meet with the constraints imposed by the future energy landscape; meshes with energy providers requirements; and has the potential to provide a substantial business opportunity.

- Trialling these intervention measures in realistic settings to understand how householders react and respond to them both in terms of behavioural interaction and in bottom line reduction in measured energy consumption, over the short term and over longer periods to understand persistence of change and prevailing impact on energy demand.

- Disseminate the collective understanding gained from this investigative process, tailoring the information for specific target audiences, including; the global public; industry and business; energy providers, government, and academics.

11a. Brief outline of project design and methodology

(It should be clear what each participant will have to do, how many times and in what order.)

The project is multidisciplinary in its approach to understanding the householder and their practice as it relates to energy consumption and to digital media. As a result the project design and methodology is reflective of the cross discipline approach. There are two over arching stages to the study, stage one involves data collection both of energy usage and human behaviour/interaction with appliances, digital media and lifestyle. The data analysis and evaluation from stage one will inform the interventions and iterative processes of stage two. The interventions are dependent on the results of stage one and therefore it is anticipated if necessary that a second ethical submission will be submitted to cover the work in stage two of the project. The longitudinal elements of the project will be covered in this ethical submission.

Stage One Part A:

- Two pre-test households, will be recruited for piloting monitoring, data collection tools and householder acceptability, This pilot will test the sensitivity of monitoring tools to detect change. The data from the pilot will inform the processes and methodologies of the main study but may not be used in the main study analysis.

- 20- 30 households will be recruited
  - Interested households will be given detailed information of the requirements of participation in the study and the time involved.
  - To ensure all household members are willing to participate in the study the researchers will visit each household and meet all the members, explaining the study at the appropriate level to all possible participants. Children will be accompanied by their responsible adult

- There will be up to four levels of engagement required from the households these are:

○ Control Households	Reading of gas and electrical meters monthly by householder and quarterly by researcher for up to three years.
○ Monitored Households	Total energy usage and monitoring of specific household appliances. Energy usage monitoring*, Observation, Ethnography, Lifestyle, Calendar Record
○ Intervention Households	As for monitored households plus Intervention strategies.
○ Longitudinal Ethnographic Households	Energy usage monitoring, Observation, Lifestyle and Intervention with longitudinal Ethnographic data

- As part of the householder's recruitment process participants will be informed of the different levels of engagement and asked to indicate the extent to which they would be willing to participate.

*Energy monitoring equipment being used is the commercially available AlertMe with additional monitoring equipment being designed and developed by Loughborough University. Relevant safety tests and risk assessment will be completed before installing in households. Water flow monitoring will require the professional instillation of a flow meter which will involve cutting the original pipe work and fitting the device.

Stage One Part B:

First visit to householders:

- All householders will have an interview to gather basic demographic and attitude to energy information (please see section 11b below for further detail. The attitude to energy will be repeated in the control households at the end of each year.
- Households will be set up over a period of a few months. It is anticipated that four homes will be bought onboard the project at anyone time.
- Monitored and Intervention Households will have either a longer interview than the control or a second interview and this will include a tour of the home with the householder during which time still photography will be taken of energy using appliances. (please see section 11b below for further detail.)

Second visit to Monitored and Intervention householders:

- Within two weeks of the interview, a researcher and an engineer will visit the homes again. The engineer will install the monitoring equipment this may involve professional trades to install inline flow meters on the hot water service. A researcher will record household calendar information with the participants.
- After the initial set up of the calendar it is envisaged that the researcher will visit the household for one to two hours every three months to review and update the calendar. Each household maybe asked to confirm that calendar activities took place and to add in any additional activities. The method and frequency of this recording will be determined by household choice and at the maximum will take 5mins daily and the minimum once every 3 months.

Third visit to Monitored and Intervention householders:

- Approximately one month after the monitoring equipment has been in place a researcher will carry out an interview with the participants
- The design researcher will carry out one or two interviews in each household each a maximum of two hours. After this they will ask participants to engage in short self recording activities on an average of approximately fifteen minutes a week, some weeks there may be a little more other weeks there will not be any activities at all. Occasionally there maybe contact visits of maximum of two hours at a time over the year.
- The ethnographer will undertake a series of research exercises focusing on domestic practices and digital media practices (as described in the information sheets). S/he will focus on sets of four (or five) homes at a time until the key practices have been examined in each of the four homes, before then moving on to the next set of four homes. Each household will be visited for one week in total in the first year. Ethnographic research exercises will also be undertaken with participants to examine their digital media use whilst out of the home.

Energy use monitoring will take place automatically over the internet and will not have any time impact on the household. Where it is detected there are any problems with the automatic monitoring, or to replace batteries, then households will be contacted and a time made to visit the household at their convenience.

All calls and visits to the households will be co-ordinated through a named researcher who will act as a primary contact point/gateway both for researchers and for the householders. All visits will take place a time that the participants chose as convenient.

It is anticipated that after the initial participant information and consent meetings, that the total no. of days to be spent in each monitored household during stage one of the project duration of 9-12 months is 20 days.

Stage Two.

The second stage of the project will include the ongoing monitoring data from stage one and the introduction of interventions in to the households. These interventions will be based upon the findings from stage one and therefore can not be defined at this stage. If the intervention work is not covered by practices already covered in this ethical submission a further submission to ethics will be made.

There will be some workshops and focus groups which participants will be invited to attend to discuss possible future technologies, this work would be covered by the generic protocol G04-P4.

At this stage is anticipated that the ethnographic observation work in stage two will be similar in duration to that in stage one. This will enable us to see the effect of the interventions. In addition the in-depth longitudinal Ethnographic study in a household – may or may not form part of the main study group. The in-depth ethnography may involve the ethnographer living alongside some of the families for a designated period agreeable to the household and my also include some degree of energy monitoring. The ethnographer will engage in the following types of activities: Cooking together with the householders, cleaning the house together, following their routes through the house, gardening, going shopping together with them, sports and other leisure activities. If this work is not covered by a generic protocol or this ethical submission a new ethical submission will be submitted

Stage Three.

1. Feedback to each household their own personal data and overall results of the study.
2. Disseminate the collective understanding gained from this investigative process, tailoring the information for specific target audiences, including; the global public; industry and business; energy providers, government, and academics this will include :
    - A book of life Stories: Dissemination to the public
    - The energy intervention rule book: 'How-to' guide aimed at product designers etc.
    - Understanding home-owners attitudes towards energy demand reduction A guide for energy providers.
    - The potential to save energy through ICT intervention in domestic property: Aimed at government to inform policy.

11b. Measurements to be taken

(Please give details of all of the measurements and samples to be taken from each participant.)

Data collection from each household will include:

Control Households

1. Demographic information
2. Attitudes to energy semi-structured interview.
3. Build structure of household
4. Floor plans of house including measurements
5. List of electrical and gas appliances
6. Rating and actual load characteristics of appliances
7. Total Energy consumption gas and electricity at Meter point taken monthly.

Monitored and Experimental Households as for Control Households plus:-

8. Location of electrical and gas appliances on floor plans – to include photographic and/or video tour of appliances in situ.
9. Appliance use information – how the householder perceives current usage.
10. Appliance 'ownership' - multiple occupants of households will have shared and personal appliance ownership.
11. Continuous energy consumption for targeted household appliances
12. Continuous hot water flow measurements
13. Continuous gas usage measurements
14. Semi - structured interview to include:
    a. attitudes to energy use/reduction
    b. use of everyday technologies
    c. descriptions of daily tasks and activities
    d. Use of digital media inside and outside the household
15. Observation of householders carrying out specific household tasks, recording mechanisms' will vary according to the appropriate recording tool for the task, these may include:
    a. Observation with note taking
    b. Observation and audio recording
    c. Observation and video recording

d. Participant audio diaries
e. Participant video diaries

All participants:

16. Occupancy patterns inside or outside of house, possibly to include location within house if technically possible and with specific consent from the participants. This may be continuous or done for short periods of time. Participant acceptance will be sought shortly before implementation of these measurements and must be agreed by all household members. Where one member does not agree, these measures will not be taken for that household and will not impact on their participation in future project activities. Likewise they may withdraw any consent to this part of the study without any questions asked of their reasons.
17. Calendar record– participants will record with the researcher their daily activities in a calendar in terms of going to work, children at school, children at afterschool activities, hobbies out of the home eg. Swimming. Participants will be asked to record if these events took place or any additional ones that took place such a number of visitors to the house including overnight stays, or having a meal. The frequency of recording will be determined by the households and the method either paper or electronic or a combination will again be driven by household choice and acceptability. It is envisaged that where an electronic calendar is used that this will be viewable on line by the researcher.

12. Please indicate whether the proposed study:

Involves taking bodily samples Yes ☐No ☒

Involves procedures which are physically invasive (including the collection of body secretions by physically invasive methods) Yes ☐No ☒

Is designed to be challenging (physically or psychologically in any way), or involves procedures which are likely to cause physical, psychological, social or emotional distress to participants Yes ☐No ☒

Involves intake of compounds additional to daily diet, or other dietary manipulation / supplementation Yes ☐No ☒

Involves pharmaceutical drugs (please refer to published guidelines) Yes ☐No ☒

Involves testing new equipment Yes ☐No ☒

Involves procedures which may cause embarrassment to participants Yes ☐No ☒

Involves collection of personal and/or potentially sensitive data Yes ☒No ☐

Involves use of radiation (Please refer to published guidelines. Investigators should contact the University's Radiological Protection Officer before commencing any research which exposes participants to ionising radiation – e.g. x-rays) Yes ☐No ☒

Involves use of hazardous materials (please refer to published guidelines) Yes ☐No ☒

Assists/alters the process of conception in any way Yes ☐No ☒

Involves methods of contraception Yes ☐No ☒

Involves genetic engineering Yes ☐No ☒

If Yes, please give specific details of the procedures to be used and arrangements to deal with adverse effects.

The demographic data and electronic data may be seen as sensitive/personal please refer to section 23 for details of arrangements for how this will be handled.

13. Participant Information

Number of participants to be recruited: 2-3 test houses, 20 - 30 Households (including controls)

Details of participants (gender, age, special interests etc):
All participants of a household:- Male, Female, Children, Elderly

How will participants be selected? Please outline inclusion/exclusion criteria to be used:
The house must not be bigger than 4 bedrooms and its location must be within 10mile of Loughborough University – this is for practical reasons only.
All household participants must be willing to take part in the project otherwise the household would be excluded as its not possible to segregate one persons energy usage from another. However it is possible for not all participants to take part in every section of the study whilst other household members do.

How will participants be recruited and approached?

The following methods of participant recruitment may be employed:

- Posters in and around public places in Loughborough, Library, John Storer House, shops
- Loughborough University Notice Boards electronic and paper
- Advertisements' in Local papers, ie: Loughborough Echo, Leicester Mercury
- Public Email Forums and Mailing lists.
- Word of mouth.
- Local radio Oak FM or Radio Leicester

Please state demand on participants' time.
In the first year 20 - 22 days (cumulatively).

14. Control Participants

Will control participants be used? Yes ☒No ☐

If Yes, please answer the following:
Number of control participants to be recruited: 10 maximum

How will control participants be selected? Please outline inclusion/exclusion criteria to be used.

a. Firstly this will be participant driven, that is choice of degree to which the participants want to be involved
b. Proximity to University
c. Ability to fit measuring kit to energy meters, those households whose meters mean this is not possible will be asked to participate as control households.

How will control participants be recruited and approached?
As for experimental participants

Please state demand on control participants' time.
2 days per year.

15. Procedures for chaperoning and supervision of participants during the investigation

Every effort will be made to invite another responsible adult to be present with the participant, and where possible, at least one other person will be present in the home (e.g. co-researcher, staff member, other responsible adult). However, since chaperoning is not always practical or possible, a risk assessment will be undertaken and proper precautions taken. If the risk is small then the investigator/researcher can visit the person's home unaccompanied. This assumes that other protection systems are in place, that is:

- Pre-arranged appointments only.
- Confirmation in writing.
- Logging the visit schedule with the supervisor or other member of staff.
- Phoning a colleague or senior investigator to confirm their safety before and after every home visit.
- Recorded conversations will also be made, if the participant agrees.
- Investigators will be made aware of the Committee's online guidance on working alone and working off-campus (http://www.lboro.ac.uk/admin/committees/ethical/gn/ciwa.htm).
- - a Criminal Records Bureau check (at enhanced level) will be undertaken, if it does not already exist for the investigator or researcher.

A designated supervisor or senior researcher will have details of the home visit beforehand and will authorise an unchaperoned home visit to go ahead, in order to ensure that the requirements under this generic protocol are adhered to. Issues that might raise the risk level above acceptable for an Unchaperoned home visit include:

- Issues of a more sensitive or personal nature may arise.
- Concern about the location of the visit.
- Uncertainty about the participant, as a result of contact already made.
- Concern by the researcher - not comfortable with an unchaperoned visit.

If, for any reason, a researcher feels uncomfortable at any time during the visit, they will be able to terminate the data collection and leave immediately. There will be no obligation to collect a 'full set' of data in these circumstances.

16. Possible risks, discomforts and/or distress to participants

The risk of injury, discomfort and/or distress will be minimal since the project is looking in to energy usage and activities as experienced by people in their daily lives. Care will be taken for sufficient breaks during interview and participants will be requested to participate in the activities and interviews, only as long as they consider acceptable. At any time participants can ask for an observer to leave without giving an explination.

17. Details of any payments to be made to the participants

No payments will be made for participation in the project, however any costs incurred by participants will be covered, so no participant should make either a loss or profit from participation in the project.

18. Is written consent to be obtained from participants? Yes ☒No ☐

If yes, please attach a copy of the consent form to be used.

If no, please justify.

19. Will any of the participants be from one of the following vulnerable groups?

Children under 18 years of age	Yes ☒No ☐
People over 65 years of age	Yes ☒No ☐
People with mental illness	Yes ☐No ☒
Prisoners/other detained persons	Yes ☐No ☒
Other vulnerable groups (please specify If party of the household)	Yes ☒No ☐

If Yes, to any of the above, please answer the following questions:

What special arrangements have been made to deal with the issues of consent?
Any participants who maybe classed as from vulnerable groups will have the study explained to them in the presence of other household members and a simplified consent form for them to sign.

A new information sheet will be provided for each stage of the study and each separate exercise which they will then be asked if they give consent to participate or not.

Have investigators obtained necessary police registration/clearance? (please provide details or indicate the reasons why this is not applicable to your study)

CRB is being obtained for all relevant researchers.

20. How will participants be informed of their right to withdraw from the study?

All participants will receive a Participant Information Sheet before consenting to participate in the project which they will then keep. In the information sheet they will be informed that they can withdraw at any time and need not inform the project of any reason why they wish to withdraw unless they desire too.

21. Will the investigation include the use of any of the following?

Observation of participants	Yes ☒No ☐
Audio recording	Yes ☒No ☐
Video recording	Yes ☒No ☐

If Yes, to any, please provide detail of how the recording will be stored, when the recordings will be destroyed and how confidentiality of data will be ensured?

All the video/audio will be kept in a secure place. Participants will be given copies of the materials we produce and will be given the opportunity to review them (this might not be until near the end of the project). Participants will be given the opportunity to let us know if there are any images or sections of footage they would not want to have published. To this end we will ask participants for initial agreement to allow us to publish the video and then give them a window of approximately four weeks in which to review any pre-publication visual texts or videos and approve them.
Third parties will have access to video/audio recordings when participants agree to these uses in the following ways

1. With the agreement of participants video/audio clips will be disseminated digitally on web sites managed by us and DVDs
2. With the agreement of participants video/audio materials will be archived and made available to other researchers
3. At the end of the project we will again revisit the conditions of use with the participants, and will ask the participants if their materials can be put in an archive for future use.

22. What steps will be taken to safeguard anonymity of participants/confidentiality of personal data?

All participants and households will be given unique reference codes. Data will be anonymised and the links between databases stored in different locations. All qualitative data will also use the reference codes.
All researches will be made aware of the university guidance on data collection and storage.

23. Please give details of what steps have been taken to ensure that the collection and storage of data complies with the Data Protection Act 1998?

Please see University guidance on Data Collection and Storage and Compliance with the Data Protection Act.

The information that can directly identify a person, such as name and addresses will be stored offline in a secured location. The anonymised data set will be made available online through a secure server. Access to this server will be restricted to the named persons on the project using a unique user name and password. Passwords will follow IT Services guidelines on password strength: http://www.lboro.ac.uk/it/doc/guidance.html.

24. If human tissue samples are to be taken, please give details of and timeframe for the disposal of the tissue.

Please note that this information should also be outlined on the Participant Information Sheet
N/A

24. Insurance Cover

It is the responsibility of investigators to ensure that there is appropriate insurance cover for the procedure/technique.

The University maintains in force a Public Liability Policy, which indemnifies it against its legal liability for **accidental** injury to persons (other than its employees) and for accidental damage to the property of others. Any **unavoidable** injury or damage therefore falls outside the scope of the policy.

Will any part of the investigation result in **unavoidable** injury or damage to participants or property?
Yes ☐ No ☒

If Yes, please detail the alternative insurance cover arrangements and attach supporting documentation to this form.

The University Insurance relates to claims arising out of all **normal** activities of the University, but Insurers require to be notified of anything of an unusual nature

Is the investigation classed as **normal** activity? Yes ☒No ☐

If No, please check with the University Insurers that the policy will cover the activity. If the activity falls outside the scope of the policy, please detail alternative insurance cover arrangements and attach supporting documentation to this form.

25. Declaration

I have read the University's Code of Practice on Investigations on Human Participants and have completed this application. I confirm that the above named investigation complies with published codes of conduct, ethical principles and guidelines of professional bodies associated with my research discipline.

I agree to provide the Ethical Advisory Committee with appropriate feedback upon completion of my investigation.

Signature of applicant: ………………………………………………………….

Signature of Head of Department: ………………………………………………………….

Date ………………………………………………………….

For all applications:

Please ensure that you have attached copies of the following documents to your submission

- Participant Information Sheet
- Informed Consent Form

In addition, please attach copies of the following documents if applicable.

- Willingness to Participate Forms
- Health Screen Questionnaire
- Questionnaires and Example Interview Questions
- Advertisement/Recruitment material
- Evidence of consent from other Committees

Appendix H: **Social Science Practice Study Overview**

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Thumbnail overview of individual family members' shower/bath routines

This table specifically relates to showering/bathing and can only be an indication or snapshot of general routines or preferences at the time of the practice visits. In some cases, we already know that things have changed due to a range of circumstances (e.g. shifts in working patterns or occupancy, seasonal changes, transitional moments, or 'phases'). *It's also important to note that these routines are not to be separated from the wider processes of using, experiencing and maintaining the bathroom, or related activities, such as media use (see 'Bathroom Summary Notes').*

	FA	MA	c1	c2	c3	GFA
01	Daily shower, first into bathroom, tries to time it for 6.45am so she can make tea for everyone at 7am. Cup of tea, breakfast with TV news (alongside	Showers every other day, not daily due to skin condition. Difficult to get up so third person in bathroom (after mc2 but before fc3). Leaves water running.	Daily shower, dislikes baths ('filthy'), last one in bathroom, spends longest in there. This was while she was only working	Showers after FA, before MA (now at uni so will not be the same routine). Leaves water running.	Evening baths, 20-30 minutes - skin condition. Audio books or reading (they have built a	-

	mc2 when he was still at home). Leaves water running during showers. Shampoo, then conditioner, body.		part-time and only later in the day. Leaves water running.		special book holder to go above the tub).	
05	Bath almost every day, usually in the morning, listening to Radio 4. Sometimes wash or shower in evening. Can’t see without glasses so prefers bath to showers. Usually very quick in and out of bath (up to 20 min), but sometimes up to two hours on weekends (tops up with warm water). Not much water but likes it very hot. Rinses hair in shower. On weekends	MA first in the bathroom, showers every other day. Starts with hot water in sink to shave. Hot showers. Quickly in and out. Baths every three months. Thinks they’re wasteful. Cleansing ‘has to be done’, not something he enjoys. Used to always shower early evening after going for a run, but this has not been possible since having the dog.	n/a	Showers and baths, sometimes shower/bath fusions. Evening rather than morning (tbc). Leaves water running when showering. Shampoo and conditioner. Reads in bath, more baths on weekends, during the day, when bored.	-	-

	listens to radio, reads or works in bath.					
30	Mainly showers, evening in winter, morning in summer. Prefers shower because of time. Washes hair every other day, sometimes during shower, sometimes leaning over the bath. Two washes, then conditioner. Leaves water running during shower.	-	Prefers baths but has more showers. Showers about once a day, baths about once a month (more on weekends). Washes hair every three to four days. Uses conditioner.	-	-	-

33	Mainly showers. If in morning, often turns on shower, goes to toilet, then straight into shower. Washes hair and body. Showers on Tues and Thurs evenings after running (either one or both parents). If cycling during the day on Wed, she'll have one shower. If cycling in the evening, she might have shower in morning and evening.	Showers most mornings, usually before doing anything else. Quickly in and out. Longer showers when he has a headache (he suffers from regular migraines) or muscle ache, cold water for tired legs. MA generally slightly cooler showers than FA but often the same. Leaves water running, unless he gets out without rinsing his hair and has to step back in again. Less baths now that they have separate en-suite. Often has baths when on business trips now.	Baths in downstairs bathroom, showers in parents' en-suite. Seemingly not every day. Baths after fc2, showers sometimes together with fc2. Baby shampoo but no conditioner, soap for body. FA warms up pyjamas for both kids on radiator. Hair washed majority of the time but not always.	Baths in downstairs bathroom, showers in parents' en-suite. Baths before mc1; skin condition so can't use soap, only baby shampoo and conditioner for hair. Spends a long time playing bath (and shower). FA warms up pyjamas for both kids on radiator. Hair washed majority of the time but not always.	-	-
37	Showers, sometimes with girls in the evening,	Shower after sports: Tues nights and Sunday mornings.	Evening showers, sometimes both girls	Evening showers, sometimes both girls	-	-

	sometimes in the morning. Shampoo, also conditioner if she has the time. Leaves water running, easier to keep it hot.	Usually just shampoo. Keeps water running. Two showers on a Tuesday as drives to work so has shower in the morning. Otherwise cycles to work and showers at work.	together but fc1 prefers having her own. Bath tub currently full of things so not used for baths. Shower also more efficient, tend to use that in the en-suite, not the electric one in the family bathroom.	together but fc1 prefers having her own. Bath tub currently full of things so not used for baths. Shower also more efficient, tend to use that in the en-suite, not the electric one in the family bathroom.		
39	Usually shower in the morning, sometimes after sport in the evening. More showers in summer, more baths in winter. Sometimes reading in bath tub for an hour. Rinses hair in bath water. Sometime washes hair in sink in winter if not	Usually showers in the morning. Keeps water running, quickly in and out. Might have another shower in the evening if hot and sweaty, especially after cycling. Very rarely a bath and only if someone else has already had one and filled the tub. Very rarely to relax	Showers and baths. Always evenings for both, more showers in school time ‘because it’s a lot easier’.	Currently still mainly baths rather than showers as she can’t reach the shower and doesn't know how to use it, though she will get help sometimes because showers use less water and it’s quicker to rinse hair.	-	-

	wanting a shower due to cold.	when aching from exercise. Bath not a place of relaxation for MA.		Used to have toys in bath but isn't a baby anymore. Usually second or last into the bath water - bath water gets shared across the family. Uses same bath water to rinse hair as it saves water and creates more bubbles. Baths once a week or once a fortnight (tbc…).		
40	Daily morning showers in family bathroom (bath once a year). Only washes hair every three to four days. Washes face separately in sink. Shampoo and conditioner.	Normally showers in en-suite, normally in the morning, but depends (working from home). Washes hair every time, no	Normally showers in the evening, every second day. During the day on Saturdays as she has swimming first and then needs a shower after dancing.	Showers morning or evenings, sometimes has a bath with his sister. Showering times depend on school clubs and related timings. E.g. if		

	Turns water off for foaming. Sometimes washes hair in the evening as it is 'better' when slept on.	conditioner. Leaves water running.	Baths mainly when she has a sore tummy, not often.	home late from school, there isn't time for shower until the morning. Not always allowed a bath, depending on time of the day.		
42	En-suite shower first thing in the morning (7am at the time), sometimes children will be upstairs and watch TV while she gets ready. Quick shower, longer and later on weekends. Leaves water running. Rarely showers later in day - usually when hot and sweaty in summer.	MA mainly away from home during the week. Has a very early shower in the downstairs bathroom (to avoid waking FA) on Monday mornings. En-suite showers on weekends, often but not always in the morning and before FA (who might be doing other things around the house first).	Afternoon baths, has started having showers. Used to share baths with mc2, now getting a bit too big (especially as they both want to lie down), so sometimes gets in after him. Very rarely morning baths, only when sick in bed overnight. Shampoo and conditioner. Has	mc2 prefers baths to showers, though is sometimes forced to have the latter because it makes things faster and easier for FA (and MA). Both fc1 and mc2 shower after swimming on Thurs.	-	-

			started showering with FA on a Monday morning. Both shower after swimming on Thursdays.			
43	Usually shower is the very first thing she does in the morning. Very hot, wakes her up. Shampoo and conditioner. On weekends, she might walk dog first and then shower.	Skin condition so does not shower every day, but mostly mornings, after FA. Has to use moisturising cream for showering, can't use soap. Lower temperature than FA. Shower quick end to the morning, would spend more time having breakfast and watching the news first.	Usually showers every night. Sometimes bath if fc2 has one, would then share the same water (one after the other). Has cooler showers than fc2. Keeps water running, no conditioner, sensitive scalp. Sometimes music on iPod while in bath.	Likes long showers, nice for night time, though sometimes also tries to get out of having a shower every day. Loves water hot for showers and baths. Baths once a week, more on weekend and only if not too late, shower duration depends on whether she wants to do something after. Washes hair every two	-	-

				days (makes 'fruit salad' out of all of the shampoos). Conditioner. Uses shampoo instead of shower gel.		
45	Shower first thing in the morning, cooler than MA. Shampoo, conditioner, face wash, likes to spend some time in shower. Irregular baths, unless in a hotel, then all the time.	MA might shower later in the day (this was when he was working from home, will have changed). Quicker showers than FA.	n/a	n/a	Showers every morning, downstairs bathroom. Shampoo and shower gel.	-
46	FA tends to shower in evenings now, sometimes in the morning, shampoo and conditioner, not much time. Leaves water running. Rarely baths, and	Showers, main in evenings, usually when kids are in bed. Leaves water running. Shampoos hair even though it is very short, for the	Children usually showered (due to time), sometimes baths on Fridays. H46fc3 first, then mc2 (sometimes together),	Children usually showered (due to time), sometimes baths on Fridays. H46fc3 first, then mc2 (sometimes together),	Children usually showered (due to time), sometimes baths on Fridays. H46fc3 first, then mc2 (sometimes	Mainly morning showers, once FA has had hers. Different on

	more so in winter. Likes baths hot.	'healthy scalp… gotta look after my hair'.	then bath tub gets refilled for mc1 (likes hotter baths and showers). All have showers Tues nights and Thursday nights, then fc3 and mc2 shower or bath on Friday but mc1 has football on Sat/Sundays so has showers then. H46mc1 tends to have his own shower, while the younger ones are showered down by FA, sometimes enjoy just sitting under the flow of water, it's a game. Shower/bath followed	then bath tub gets refilled for mc1 (likes hotter baths and showers). All have showers Tues nights and Thursday nights, then fc3 and mc2 shower or bath on Friday but mc1 has football on Sat/Sundays so has showers then. H46mc1 tends to have his own shower, while the younger ones are showered down by FA, sometimes enjoy just sitting under the flow of water, it's a game. Shower/bath followed	together), then bath tub gets refilled for mc1 (likes hotter baths and showers). All have showers Tues nights and Thursday nights, then fc3 and mc2 shower or bath on Friday but mc1 has football on Sat/Sundays so has showers then. H46mc1 tends to have his own shower, while the younger ones are showered down by FA, sometimes enjoy just sitting under the flow of water, it's a	Friday because of different work pattern and wanting to freshen up after work (afternoon). Not as hot as MA. Shampoo and conditioner. Longer on Fridays. Occasional bath to relax but struggles to get in and out. Takes a

			by ‘down time’ in front of the Simpsons.	by ‘down time’ in front of the Simpsons.	game. Shower/bath followed by ‘down time’ in front of the Simpsons.	long time to fill, big bath.