Thinking Smart: Understanding citizen acceptance of smart technologies in future cities

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Thesis Abstract

The sustainability challenges that are threatening cities are increasingly being tackled through the use of smart technologies. These smart technologies have implications for the citizen; however, the current discussions of smart citizens within the extant literature were found to be abstract and limited in their considerations. The aim of this thesis, therefore was to explore the smart citizen concept, from a psychological perspective, in terms of factors influencing smart energy technology acceptance.

Study 1 investigated the smart city and smart citizen in order to gain further understanding of the current issues and potential challenges. As such, interviews were conducted with UK city stakeholders who were involved in smart city initiatives. Overall, they felt that citizens should sharing the goals for smart city developments and pursuing goals for the collective benefit.

Studies 2a and 2b used the extended technology acceptance model (TAM2) in conjunction with psychological empowerment, environmental concern, and environmental citizenship to predict participants' intention to use a home energy management system (HEMS) to engage in either energy reduction (2a) or load shifting (2b). Study 3, used the same factors to again explore acceptance of the HEMS, however the HEMS and load shifting were then framed with either a gain goal-frame or a normative goal-frame, as per goal-framing theory. The framing of the information across the studies led to different factors being significant in each of the predictive models.

This thesis concludes that internalised goals may undermine the effect of more individualistic concerns for intention to use a HEMS. As such, the internalisation of wider collective national or city goals by citizens will be a critical aspect of citizen engagement and empowerment within the smart city and is likely to be important in supporting the roll out of smart technology and the achievement of the smart city strategies.

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Chapter 1: Introduction

This thesis explored the intersection between energy, cities, and people. At this intersection and common to all three of these areas, is technology (see Figure 1 for thematic concepts). This is due to the rapid pervasion of information communication technologies (ICT) over the last decade, which has meant that digitally connected, smart technologies are starting to impact on many aspects of our daily lives (e.g. Wilson et al., 2015) and technological solutionism predominates strategies for urban development and sustainability (Morozov, 2013). Indeed, as cities are a convergent point for many services, amenities, employment, and leisure activities, they are also a convergent point for smart technologies for citizens to interact with and utilise.

This pervasion and predominance of ICTs means we increasingly inhabit new types of “smart environments” (D. Cook & Das, 2004, 2007; Kiljander, Takalo-Mattila, Eteläperä, Soininen, & Keinänen, 2011). From smartphones, to smart communities; from smart government, to smart cities; and from the individual, through to the collective; all are becoming increasingly “smart” through digital connectivity and ICTs (see Chapter 2, Table 3**)**. Indeed, strategies for city development are increasingly focused on using ICTs to create smarter cities. Therefore, this thesis adopted an environmental psychology perspective to explore the increasing use of information communication and digital technologies (so-called smart technologies) to achieve greater sustainability in cities. In particular, the role of the citizen was considered in relation to broad smart city strategies as well as smart grids and smart energy technologies. It was argued that the citizens’ engagement with and acceptance of smart technologies will be a necessary part of achieving smart, sustainable cities. The remainder of this chapter gives an overview of the context of urbanisation in which smart technologies are being employed.

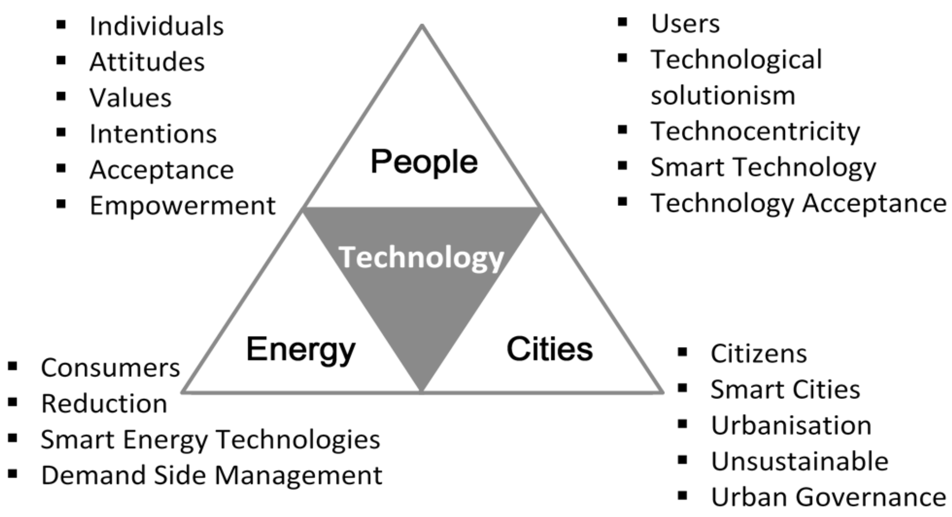

Figure 1. Conceptualisation of themes in thesis

1.1 Challenges of Urbanisation and Evolving Cities

Environmental psychology, at its core, is concerned with people and their reciprocal relationships with the spaces and places they inhabit (Gifford, 2014). The environment we occupy, whether it is natural or built, influences us. It varies in what it can afford us (Adevi & Grahn, 2011; Uzzell, 1991), what it means to us (Lewicka, 2010), and it has an impact on our wellbeing (Björk et al., 2008; Hägerhäll et al., 2010; Sundquist, Frank, & Sundquist, 2004). Likewise, humans impact on their environment, whether through construction, agriculture, or simply passing through it (Goudie & Viles, 2013). The impacts of human activity on the natural environment, for instance, are so numerous and complex, that the full implications are still becoming apparent (Crutzen, 2006; Giddings, Hopwood, & O'brien, 2002; Groombridge & Jenkins, 2000).

Perhaps some of the most significant long-term alterations to the natural environment are because of urbanisation processes and the associated increase in the size of cities (Henderson & Wang, 2007). Urbanisation is a phenomenon which can be considered a process of population concentration (Tisdale, 1942) and it is currently occurring globally and rapidly. For instance, over 50% of the world's population are now living in cities and this percentage is predicted to increase to 67% by 2050 (Economic & Social Affairs, 2014). This increasing concentration of global populations in cities is due to a combination of continued urbanisation and a global growth in population (Satterthwaite, 2007). Such continued, large-scale urbanisation raises issues of environmental, social and economic sustainability for many cities. These challenges include high levels of air pollution, increased environmental degradation and consumption of energy, water, and other resources (International Energy Agency, 2008; Maeda & Hirose, 2009; Satterthwaite, 2007, 2008); and a greater level of socioeconomic inequality, and health risks (Alathur, Ilavarasan, & Gupta, 2011; Behrens & Robert-Nicoud, 2014; Fraunholz & Unnithan, 2009). As such, there are now objectives for reductions in CO_2 emissions (Dixon, 2012) and other environmental impacts (Royal Commission, 2007).

Despite the high resource usage and CO_2 production associated with cities (International Energy Agency, 2008; Satterthwaite, 2008), there is potential for cities to become much more resource efficient. For instance, the densification of cities, sometimes termed 'compact cities'(Burton, Jenks, & Williams, 2003), can offer opportunities for greater energy efficiency. This is demonstrated by the observation that per capita, cities, such as New York, often have lower carbon footprints than surrounding rural areas (Stone et al., 2007). Although not all studies have found compact cites to have environmental benefits (see Neuman, 2005 for a review), it is argued that compact cities, compared to rural areas or suburbs, can reduce the need for cars, reduce opportunities to be wasteful, and encourage smaller family sizes (Owen, 2009). In addition, due to their concentration of human activity, cities can offer opportunities to explore and test innovative climate initiatives, which can then lead to changes to the wider systems (Freytag, Gössling, & Mössner, 2014).

The challenges presented by rapid urbanisation and the opportunities for efficiency and innovation, mean that there is an increasing focus from urban developers and policy makers on how the cities of the future can be developed to sustain or increase the economic opportunities, social benefits, amenities, and services that they offer (Lombardi, Porter, Barber, & Rogers, 2011). In particular, ICTs are increasingly being leveraged to support many environmental sustainability initiatives (Kranz, Kolbe, Koo, & Boudreau, 2015). For instance, ICTs are being used to change the distribution and generation of electricity (Gungor et al., 2013), and “shift” when it is consumed (Gelazanskas & Gamage, 2014; Siano, 2014). This use of ICTs to find solutions to urbanisation challenges has recently been captured in the discussion and implementation of the smart city concept.

The smart city concept and subsequent strategies focus on the use of information communication technologies (ICTs) to improve city management and solve urban challenges (Harrison et al., 2010; Washburn & Sindhu, 2010). Smart cities represent the current pinnacle of applying technology to our urban environments in order to solve urbanisation challenges. The continued adoption and utilisation of smart city strategies by the European Union and countries globally suggests that citizens will be increasingly living in smart technology-enabled cities, communities, and homes (e.g. EIP, 2013; Wilson et al., 2015).

Although smart cities have been subject to increasing discussion within the literature (de Jong, Joss, Schraven, Zhan, & Weijnen, 2015), there has been relatively limited discussion of what smart city based strategies require from or mean for the citizens i.e. the smart citizens (Harrison & Donnelly, 2011). Often, as the conceptualisations for urban development evolve in response to urban challenges, so too do the discussions of the citizen, such as ‘digital city’ and the ‘digital citizen’ (Ergazakis, Ergazakis, Askounis, & Charalabidis, 2011; O'Hara, 2013) or the ‘green city’ and the ‘green citizen’ (Bell, 2004; Campbell, 1996). Typically within these discussions is there is a focus on the role of the citizen in urban development (Marsal-Llacuna & de la Rosa-Esteva, 2013) within both communities (Ohmer, 2007), city services (J. Lee & Lee, 2014; Marsal-Llacuna, Leung, & Ren, 2011), and government (Winkler, Ziekow, & Weinberg, 2012). Frequently, the focus is on citizen participation and citizen engagement, particularly when considering the environmental, social and economic sustainability of the city (Doelle & Sinclair, 2006; Portney, 2005; Portney & Berry, 2010).

A key argument in the thesis is that aspects of the smart city can be rolled out with only limited engagement from citizens. However, to realise the full potential of the smart city may require citizens to be actively enrolled in the smart city network as active consumers and environmental citizens who adopt the shared goals of the city (Caragliu & Del Bo, 2012; Dobson, 2007; Harrison & Donnelly, 2011). As such, this thesis is interested primarily in the factors that might influence citizen acceptance of the technologies and goals of smart city strategies.

The thesis begins with a broad perspective to understand the citizens’ role in achieving smart, sustainable city strategies. The perspective then focuses in on smart energy technologies, as these are a key aspect of smart city strategies and require acceptance and participation from householders. The aim is to develop the smart citizen concept and identify psychological factors of the citizen that will have a bearing on the development of smart cities. These factors include technology acceptance, environmental citizenship, environmental concern, and empowerment. These are identified as being important factors in smart city developments in Chapters 2 and 4. Their importance in influencing householder acceptance of smart energy technologies are then quantitatively explored in Chapters 5 and 6.

Chapter 2: Literature Review

The continued trend of applying Information Communication Technologies (ICTs) to our environments (e.g. cities, homes) has been encapsulated in the smart city concept (Bach & Schütz, 2011; Dirks & Keeling, 2009; Lombardi et al., 2012; Neirotti et al., 2014; Toppeta, 2010). In many respects, the development of a smart city can be seen as continuing a long-standing practice of improving the operational efficiency and quality of life of a city through advances in ICT (Harrison et al., 2010). However, the smart city is a concept which is still evolving in its definition and pursuing a smarter city is considered a process, rather than as an end state (BIS, 2013). This literature review explored the smart concept and the characterisation of the smart citizen within academic literature.

2.1 The Smart City

The smart city concept began as a seemingly technocentric[1] and technocratic[2] vision of the future urban environments where all sustainability and management challenges would be solved by ICTs (Hall, 2000). As such, the early discussions of the smart city concept were on how the ICTs will enable innovations within city management through the provision of real-time information and greater digital connectivity between services and infrastructure. Such connectivity is still at the centre of the smart city concept (Batty et al., 2012; Harrison et al., 2010; Hernández-Muñoz et al., 2011). As such, the smart city concept is very much

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[1] Technocentric beliefs or values hold that technology can solve all problems (Olphert & Damodaran, 2007)
[2] Technocracy is a political concept wherein a society is governed by those with technological or scientific expertise (Sylvain, 2013)

driven by advances in ICT and associated technologies, such as wireless broadband, 4th generation (4G) mobile networks, analytical software and real-time sensing of the infrastructure and occupants of the city (Avelar et al., 2014; Cimmino et al., 2014; Graham & Marvin, 2001; Harrison et al., 2010; Piro, Cianci, Grieco, Boggia, & Camarda, 2014). Increasingly, however, the smart city concept has also been defined with a broader variety of strategy and visions.

The smart city, as with other city concepts, have strategies and objectives, including for the preservation of the city (Hodson & Marvin, 2010). In line with this, a common goal of the smart city strategies is the utilisation of technological innovation to solve the challenges associated with urbanisation and to improve the sustainability of the urban space (Mosannenzadeh & Vettorato, 2014). Environmental (or ecological) sustainability, for example, is approached through the technologies themselves becoming more efficient (Kramers, Höjer, Lövehagen, & Wangel, 2014) or by technologies being used to ensure greater efficiencies of resources use, such as by monitoring water usage or reducing energy waste (Harrison et al., 2010; Kitchin, 2014). Technologies may also be implemented to facilitate or encourage users' behaviour change and the reduction of the users' energy consumption (Goulden et al., 2014).

As well as environmental sustainability, economic growth is a key ambition within the smart city concepts (Caragliu, del Bo, & Nijkamp, 2011; Nam & Pardo, 2011a). Smart city leaders intend for the growth of technological industries to attract and facilitate skilled, creative workers and entrepreneurs, who wish to benefit from the opportunities of a technologically advanced city and whose labour will contribute to the city's economy (Hollands, 2008). In addition, in terms of social sustainability, it is envisioned that smart cities should help foster smart communities. These are seen as being communities of interest and place resulting from the use of ICTs to communicate, coordinate and participate in activities (Krebs & Holley, 2006; Li et al., 2011), with problems or issues reported directly to their local or regional authorities (Gonçalves et al., 2013).

The European Commission has recognised the importance of smart cities for shaping and sustaining urban environments and quality of life. Smart cities are part of their strategy to reach the European Union's 2020 targets for a 20% reduction in greenhouse emissions across Europe (based on the 1990 levels). In the 2009 SET-plan — Investing in the Development of Low Carbon Technologies (European Commission, 2009) — the European commission argued that energy efficiency is the simplest and cheapest way to reduce CO_2 emissions. Accordingly, the European Smart Cities Initiative[3] was established with the objective to "create the conditions to trigger the mass market take-up of energy efficiency technologies" (European Commission, 2009, p. 7) and support pioneer cities. The European Innovation Partnership on Smart Cities and Communities initiative (EIP-SCC) followed in 2012[4]. The EIP-SCC is a partnership across the areas of energy, transport and information and communication. Its objective is to: "catalyse progress in areas where energy production, distribution and use; mobility and transport; and information and communication technologies (ICT) are intimately linked and offer new interdisciplinary opportunities to improve services while reducing energy and resource consumption and greenhouse gas (GHG) and other polluting emissions" (European Commission, 2012, p. 2). Consequently, there are a number of smart city projects occurring across Europe, with a particular focus on the energy sector (see Table 1 for examples of projects through the EIP-SCC. For a full list and further details, see: https://eu-smartcities.eu/eu-projects).

3 http://ec.europa.eu/eip/smartcities/
[4] http://ec.europa.eu/eip/smartcities/index_en.htm

Despite the adoption of smart city strategies and broad visions for connectivity and sustainability, there still remains a fuzziness and flexibility in the use of the term smart city (Hollands, 2008).

Table 1. Examples of EIP Smart Cities and Communities projects

Project title	**Location(s)**	**Brief Description**
InSMART – Integrative Smart City Planning	Trikala, Cesena Évora, Nottingham, Lisbon, and Pikermi	"The InSMART concept (Integrative Smart City Planning) brings together cities, scientific and industrial organisations to establish and implement a comprehensive methodology for enhancing sustainable planning"*.
STEEP – Systems thinking for comprehensive city efficient energy planning	San Sebastián – Donostia, Bristol, and Florence,	"Improve efficiency along all the key aspects of their energy value chain, by applying smart city concepts in an integrated manner while learning from each other's expertise and viewpoint in applying sustainable practices".
STEP UP - Strategies Towards Energy Performance and Urban Planning	Ghent, Glasgow, Gothenburg, and Riga	"STEP UP is an energy and sustainable city planning programme that aims to assisting cities to enhance their sustainable energy action plans and integrating energy planning into their sustainable city planning".
CELSIUS - Combined Efficient Large Scale Integrated Urban Systems	Gothenburg, London, Rotterdam, Genoa, and Koeln	"CELSIUS demonstrates and promotes integration of smart district heating and smart district cooling".

*Quotes take from https://eu-smartcities.eu/eu-projects. Last accessed 05/06/2016.

2.1.1 Identifying and Comparing Smart Characteristics

The broad and evolving definitions of what makes a city smart (as opposed to not smart), both in Europe and Internationally, is a recognised problem within the literature (BIS, 2013) and a number of recent attempts to conceptualise the smart city have been made (BIS, 2013; Caragliu et al., 2011; Hollands, 2008; Lazaroiu & Mariacristina, 2012). Part of the difficulty of defining a smart city is the multiple factors that can be argued to contribute to smartness and the different levels of importance that are attributed to each factor depending on the priorities or objectives of the city, government body, academic or industry (Lazaroiu & Mariacristina, 2012). Furthermore, some factors may more often take precedence over others (e.g. business needs over environmental ones; see Hollands, 2008). To some extent, such variation in the use of the smart city concept should be expected as there is arguably no "one-size-fits-all" approach to city innovation (Eger, 2009). Each group of city leaders will understandably develop the area of the smart city concept that most readily address their local needs. Therefore, a city can have a number of smart projects within different domains and services and each will have their own difficulties, challenges and objectives, however, they could all be deemed as contributing to the development of a smart city. Indeed, Giffinger et al. (2007) noted that the term smart city was not used in a holistic way to describe a city with certain definitive attributes, but was instead used for various discrete characteristics of a city, which vary from city to city (Gifinger et al, 2007).

Despite (or perhaps, due to) the variation in projects occurring under the label of smart city, a number of research papers currently in the literature focus on ways of assessing and comparing a city's 'smartness'. This is done by identifying the common features of cities that have adopted the label "smart" and the characteristics that are otherwise discussed within the literature as being important for the development of a city as "smart". For example, in an early effort to enable the objective comparison and ranking of medium sized, European cities in terms of their smartness, Giffinger et al. (2007) suggested six characteristics of smart cities (see Table 2). Broadly, they considered a smart city project to be "well performing and forward looking" in its approach to the six areas: Smart economy (competitiveness); Smart People (social and human capital); Smart Governance (Participation); Smart Mobility (Transport and ICT); Smart Environment (natural resources) and Smart Living (quality of life). These six characteristics of the smart city have been adopted by other modelling studies (Lazaroiu & Mariacristina, 2012; Lombardi et al., 2012) and used as a basis in smart city conceptualisations (Nam & Pardo, 2011a).

The smart city concept, therefore, is not just the deployment of technology within a city. Greater digital connectivity and the resulting potential for new forms of city management is what is argued to lead to the smart characteristics outlined by Giffinger et al. (2007) or by Chourabi et al. (2012). Indeed, Nam and Pardo (2011b) moved away from the ranking of smartness and suggested that the smart city concept is not a status of how smart a city is, but it is an indicator of a city's efforts to become smart through ICT enabled innovation. It is the ICT that is viewed as the main enabler of the smart city developments and what differentiates the smart city concept from other future city conceptualisations (and from past city conceptualisations), however, there is a need for the non-technical aspects of the smart city to also be considered.

Table 2. Characteristics of a Smart City (Giffinger et al., 2007)

Smart Economy (Competitiveness)	**Smart People** (Social and Human Capital)
• Innovative spirit • Entrepreneurship • Economic image and trademarks • Productivity • Flexibility of labour market • International embeddedness • Ability to transform	• Level of qualification • Affinity to life long learning • Social and ethnic plurality • Flexibility • Creativity • Cosmopolitansim/Open-mindedness • Participation in Public Life
Smart Governance (Participation)	**Smart Mobility** (Transport and ICT)
• Participation in decision-making • Public and social services • Transparent governance • Political strategies and perspectives	• Local accessibility • (Inter-)national accessibility • Availability of ICT- infrastructure • Sustainable, innovative and safe transport systems
Smart Environment (Natural resources)	**Smart Living** (Quality of life)
• Attractivity of natural conditions • Pollution • Environmental protection • Sustainable resource management	• Cultural facilities • Health conditions • Individual safety • Housing quality • Education facilities • Touristic attractivity • Social cohesion

2.1.2 Pervasive Smart Technology

The vision of smart technologies is that digitally connected technology will be pervasive and ubiquitous (Hancke & Hancke Jr, 2012; Harrison & Donnelly, 2011; Kitchin, 2014; Klein & Kaefer, 2008; Naphade, Banavar, Harrison, Paraszczak, & Morris, 2011).

Table 3 highlights some of the areas where smart technologies are going to be/are being applied to (i.e. where the smartness goes).

The apparent range over which the smart city concept (and its associated smart technologies) is being applied makes it difficult to identify singular or even direct implications for the citizens. Indeed, some smart city developments may be able to occur without any citizen engagement or participation. However, there are (and will be) smart city technologies that do involve citizen interaction. For instance, the smart energy devices being developed for smart homes (Nazabal, Fernandez-Valdivielso, Falcone, & Matias, 2013) will be the householders' point of interaction with the smart grid and as such, the smart city (Naus et al., 2014). The rise in smartphone sales and their increased functionality (Pettey & van der Meulen, 2012) mean that the smartphone will frequently be the citizens' point of interaction with each other, the city's services and the city's governance through real-time information applications (apps) and community apps and (Boulos, Wheeler, Tavares, & Jones, 2011). Within public spaces, urban screens and city dashboards will be the citizens' point of interaction with their city's infrastructure, their community and their local authority (Bobker, 2011; Kitchin, 2014; Schroeter, 2012; Struppek, 2006) with increasingly complex data being visualised in public spaces (Valkanova, Jorda, & Moere, 2015). Even healthcare will increasingly be provided through telehealth and other smart home care systems (Leijdekkers, Gay, & Lawrence, 2007; Martin, Kelly, Kernohan, McCreight, & Nugent, 2008).

Due to this increasing interaction between the smart citizen and smart technologies, the citizen will have a role in the implementation of the technology and in achieving the agenda of the smart city strategy. Such pervasiveness means understanding the factors affecting citizen acceptance and use of smart tech will be important to the success of smart cities.

Table 3. Where the Smartness Goes

Smart Transport	Greater use of technology at all levels of transport, from greater connectivity and analysis of road networks to improve efficiency, through to implementation of electric vehicles (Allwinkle & Cruickshank, 2011; Caragliu & Del Bo, 2012; Nam & Pardo, 2011a).
Smart Grids	A concept for the next generation of electricity grids, which have advanced monitoring and control technologies to allow for optimal balancing of the load and supply (Gungor et al., 2013; R. H. Khan & Khan, 2013).
Smart Home	The combination of energy management technologies, smart appliances, and connected devices and systems (including lighting, heating, and ventilation), which automate the home and/or provide the homeowner with more information and/or remote control (Paetz, Dütschke, & Fichtner, 2012; Wilson, Hargreaves, & Hauxwell-Baldwin, 2015).
Smart Energy Technologies	Beginning with smart meters, a range of In Home Displays and Home Energy Management Systems to provide consumers with near-real-time information about their consumption and the market price of electricity (Krishnamurti et al., 2012; Schultz, Estrada, Schmitt, Sokoloski, & Silva-Send, 2015).
Smart Communities	Members of a community (including local governments, businesses, homeowners etc.) utilising information communication technologies to bring benefits to their region (Lindskog, 2004).
Smart Governance	ICTs enable the city administration to have a smart government, which is capable of "reaching its citizens effectively. Use of e-government (Washburn & Sindhu, 2010).
Smarter Services	Public safety will improve through the use of real time information to respond rapidly to emergencies and threats (Washburn & Sindhu, 2010).
Management of City	Development of ICT driven dashboards to summarize the current condition of the city to aid local governments' decision making (Suakanto, Supangkat, & Saragih, 2013)
Smartphones and Applications	The smart phone is likely to act as a gateway to many of the smart city features, such as data, and will be the predominant way citizens interact with the city (Neirotti, De Marco, Cagliano, Mangano, & Scorrano, 2014; Shelton, Zook, & Wiig, 2014).

2.1.3 The Smart Agenda

Increasingly it is being recognised that, whilst technology can play a role in shaping new norms of behaviour intended to facilitate the continuing growth of dense populations (Harrison & Donnelly, 2011), the smart city will also be shaped by the citizens' use of the technologies. For instance, the common feature of many of the anticipated technological benefits of smart cities is that they rely on citizens changing their behaviour (Goulden et al., 2014). The implication of this is that the successful introduction of smart city technologies will, to varying degrees, require the cooperation of citizens (e.g., in terms of adopting new technology, adopting the smart city goals and accepting the implications, or consenting to provide access to personal data) and/or changes in their behaviour (Harrison & Donnelly, 2011).

The behaviours currently discussed in the smart city literature include governance related behaviours, such as voting or reporting of problems in local areas (Gonçalves et al., 2013; S. F. King & Brown, 2007); transport related behaviours, such as greater use of public transport (Farkas, Fehér, Benczúr, & Sidló, 2014); and energy management behaviours, such as remote managing household heating and/or the monitoring household electricity usage (Dimitrokali et al., 2015; Miller & Buys, 2010; Paetz et al., 2012). There may also be social or hedonistic technologies (Harper, 2006; Kamilaris & Pitsillides, 2010) or even ones for self-management or betterment, such as in health and fitness (Nisheeth Gupta & Jilla, 2011). These examples are by no means exhaustive, and as smart technologies continue to pervade urban environments, citizens' behaviours will be increasingly guided, aided, or constrained by the technologies around them. The list of examples will grow, and the implications will too. Therefore, smart citizens will need to not only understand the streams of information provided to them through the smart city system, but also subsequently support the city's intended goals through their own decisions (Harrison and Donnelly, 2011).

Accordingly, Hollands (2008), as well as others (Paquet, 2001; Lindskog, 2004; Nam and Pardo, 2011), have argued that the implementation of technology, although requisite and enabling, is not enough to make a city smart. Indeed, a burgeoning literature now exists to indicate that addressing institutional and non-technical considerations will be integral to the successful development of smart cities (Arribas-Bel, Kourtit, & Nijkamp, 2013; Chourabi et al., 2012; Giffinger et al., 2007; Kourtit, Nijkamp, & Arribas, 2012; Lombardi, Giordano, Farouh, & Yousef, 2012). Lindskog (2004), for instance, argues that without the engagement of public institutions, private sector, voluntary organizations, schools and citizens there will not be a smart city.

In sum, the technology of a smart city has the potential to facilitate sustainable urban areas; however, it is argued that more than just the implementation of efficient, interconnected technology is required. People and communities within society have to make changes in their lifestyles and consumption, which in the case of the smart city, means greater use of smart technologies.

2.1.4 Smart Citizens

Whilst the smart city concept has seen a recent exponential rise in the number of articles relating to its development (de Jong et al., 2015), the concept of what should constitute a "smart citizen" remains comparatively underdeveloped (Harrison & Donnelly, 2011). The smart city comparison studies described earlier, have acknowledged "People" as factors of a smart city and defined the characteristics in an attempt to quantify whether the citizens in one city are more or less “smart” than citizens in another city (Giffinger et al., 2007; Kourtit et al., 2012; Lombardi et al., 2012). As a result, the ability of a city to improve its relative position in global smart city rankings will be partially determined by the “smartness” of its citizens (Giffinger, Haindlmaier, & Kramar, 2010). However, despite these characterisations, what it means for a citizen to be “smart” is only beginning to be discussed by city stakeholders (see: Hemment & Townsend, 2013) and it has yet to be standardised between studies or models.

Table 4 shows the ways in which citizens have previously been characterised within benchmarking studies and across smart city discussions. In particular it shows the studies which have aimed to (a) develop ways of objectively comparing the smartness of different cities, or (b) that have discussed the characteristics that a smart city should foster in (or demand of) its citizens. I have thematically grouped the characteristics into those which broadly reflect “human capital”, “empowerment”, “engagement” and “citizenship” attributes and values, to allow for easier comparison, and to aid the development of the interview questions for Study 1. Whilst it is possible to loosely group the characteristics used to describe smart citizens across studies, the characteristics are limited in their considerations; they are abstract and rely on inference, and there is a need to operationalise them. Each of these points are expanded below.

Table 4. Smart People characteristics developed from descriptions and discussions within smart city literature.

	Human Capital	Empowerment	Engagement	Citizenship
Giffinger et al. (2007)	A good level of qualification Affinity to lifelong learning Flexibility Creativity	Self-decisive Independent	Aware	Social and ethnic plurality Cosmopolitanism/Open-mindedness Participation in public life
Hollands (2008)	Possess skills necessary to utilize ICTs (ICT Literate) Benefit from the technologies		Consenting to changes	Sense of belonging (place attachment and identity) Socially cohesive
Lombardi, Giordano, Farouh, and Yousef (2012)	Participate in life- long learning Computer literate Speak foreign languages.		Engaged in government Make use of local amenities (book loans and theatre, cinema and museum visits)	Local identity Socially included Use public transport, walk or cycle to work.
European Commission (Communities, 2009)		Empowered	Engaged Accepting of new solutions (both technical and non-technical).	
Winters (2011)	Better-educated			

Table 4. (Continued)

	Human Capital	Empowerment	Engagement	Citizenship
Streitz (2011)		Empowered		Socially aware
Glaeser and Berry (2006)	Skilled Workers			
Harrison and Donnelly (2011)	Rational decision-making		Understand the purpose of the smart city system and support its goals.	
Caragliu and Del Bo (2012)			Make use of local amenities	
Kourtit, Nijkamp, and Arribas (2012)	Employed in "financial intermediation and business activities" Secondary level education.			
Chourabi et al. (2012)	Better educated	Participate in city governance and management	Informed	Active users of the city Community member

N.B. Literature was identified by using a keyword search of the journal database, Scopus. Key words used were: "Smart Cit*", "smart citizen*" "smart people".

Limited Considerations: As shown in Table 4 the attempts to rank and compare cities in terms of their smartness have used different factors and data to characterise the "smarter" citizen, however there is strong focus on human capital (Giffinger et al., 2007; Kourtit et al., 2012; Lombardi et al., 2012). Whilst human capital indicators (such as employment, skills and education) are important considerations for the economic success of the smart city, they result in citizens being considered as commodities and/or products of a smart city and fail to consider *how* citizens will perceive and interact with the city, or *how* they will contribute to its evolution and development.

Abstractedness & Inference: Many of the smart citizen characteristics listed in Table 4 (such as flexibility, empowered, open-mindedness or creativity), are multi-faceted, abstract terms that have yet to be fully operationalised within discussions or studies of smart cities. The smart city comparison studies, for instance, have typically relied on proxy data to make inferences about the indicators of smartness. For instance, the amount of lifelong learning citizens engage was inferred from the number of books loaned from the city's library (Giffinger et al., 2007). The abstract nature of the terms creates a barrier to implementing and assessing interventions that impact on these areas.

Need for Operationalisation: Papers and city literature which do discuss smart citizens in abstract ways (e.g. Streitz, 2011) also do not consider how such abstract constructs may be assessed more directly or how they may interact and influence citizens' perceptions and interactions with the smart city. While ranking studies are frequently limited by the data that is available to them at a city level, making inferences from proxy data almost inevitable, Giffinger et al. (2007) provide no suggestion as to how these smart people characteristics may be more directly measured. Only through identifying and operationalising the key characteristics of the smart citizen can they be further understood, measured and utilised within smart city projects, rather than just discussed as abstract ideals or inferred through proxies.

To probe the characteristics a little further, the "Smart People" characteristic used in Giffinger et al.'s (2007) measures considered the intelligence of the city's inhabitants operationalised by their level of qualification. This is quite a literal consideration of the term smart and is used by Winters (2011) to discuss why there are a greater number of people with higher-education qualifications in cities and how this leads to the attraction of individuals seeking higher education, thus leading to population growth within these ''smart" cities. Whilst smart city initiatives are concerned with attracting the intelligent, creative future generations, a measure of education seems crude and unlikely to be related to factors that will influence how people live in the city, how they interact with services and cope with new technological demands. The other smart people factors suggested by Giffinger et al. (2007) are not discussed within the paper, but represent abstract, multi-connoted ideals that offer little by way of characterisation and provide no insight into the characteristics of those people who will thrive in a smart city environment and those who will struggle.

Such superficial consideration of human factors occurs in other studies which have aimed to compare smart cities. A recent, benchmarking study by Kourtit et al. (2012) used different characteristics and indicators, to compare nine European cities. Only "proportion of employment in financial intermediation and business activities" and "proportion of population aged 16-64 with secondary level education" were measured in relation to human factors. In a further study, Caragliu et al. (2011) formed a composite indicator of a city's 'smartness' from the averaging "the number of visitors to museums per resident", "the length of public transportation" and "the number of administrative forms available for download from official web site". They argue that the first component accounts for the role of efficiency in exploiting urban amenities, the second the contribution of transport infrastructure to urban competitiveness and the third, the e-government side of the concept.

Whilst the composite indicators generated by Caragliu et al. (2011) may offer discrete, indicators of how citizens are using and are able to use the city, it is unlikely that the use of museums can be extrapolated to understand how citizens are choosing to interact with their cities. Furthermore, the authors would have to have assumed a lot about the citizen in terms of how and why the citizens do/do not visit museums or do/do not use the online forms. In short, these indicators are not able to tell us anything about the citizens' motivations for intentional/actual usage of the city amenities.

Perhaps it is due to the challenges of assessing abstract characteristics or perhaps to the technocentric dominance in smart city strategies, but city leaders around the world have considered the technological development aspect of smart cities more than they have the citizens. Alawadhi et al. (2012) conducted interviews with government officials and managers responsible for current smart city initiatives being undertaken in four North American cities. The authors noted that respondents "talked more about technology, management and organization, policy context, and governance, than the other areas" (p. 46). This suggests that "people and communities" are being considered less within smart city initiatives than other areas. When these governments discussed "people and communities", they centred on participatory government through the use of technology and social media. There was no discussion of engagement or ensuring technology acceptance and/or inclusion.

Beyond the attempts to identify and measure aspects of the smart citizen, discussions of citizens within smart city concepts often contain implicit or assumed characteristics. Hollands (2008), for example, suggests that smart city developments need to have increased citizen participation within government. This is also argued within many smart city visions (such as with, Smart Government, Giffinger et al., 2007 or e-government, Anthopoulos and Fitsilis, 2010) with government processes becoming more transparent and citizens having greater participation in the governance and management of the city. In line with this, Harrison et al. (2010), argues the smart city strategies should foster more informed, educated, and participatory citizens. Similarly, the participatory citizen is described as being, better informed, more educated and an active user of the city (Chourabi et al., 2012). The aim is to give members of city the opportunity to engage with city initiatives to such an extent that they are influential to its success or a failure (Harrison et al., 2010). Such discussions of the future, smart citizen raise initial questions relating to how will they become better informed and what will they become informed about, but also, and perhaps most pertinent to this review, why will they want to become informed, what will motivate a citizen to be "smart" and participate and be active?

If the smart city should strive for engaged, informed, and participatory citizens, then a characteristic of a smart citizen could be their level of engagement with their city and its smart infrastructure. The individuals' attitudes, values and beliefs will drive their engagement and so these need to be identified in relation to the smart city factors in order to establish if they are prepared for the engagement, collaboration and cooperation with the council, government and each other, that is seen as integral to the smart city agenda. Therefore, more research is needed to identify the factors underlying the acceptance of smart city infrastructure. This would help us operationalise more effectively and tell us more about the underlying motives.

2.1.5 Conclusions

To date, little research has been conducted on the smart citizen and their role in achieving the multiple goals of the smart technologies. Therefore, there is a need to develop testable hypotheses of the characteristics and indicators that may be important to allow an understanding of the smart city developments from the perspective of the citizen. Although they provide a basis for understanding the characteristics of a citizen that are likely to promote engagement with future cities, the current characterisations, operationalization and definitions of the smart citizen are too superficial, abstract and vague. As such, I argue that there is a need to develop an understanding of the smart citizen at the level of attitude, beliefs and values level in order to allow assessment and exploration of whether citizens are prepared for smart city developments and to meet the idealised smart citizen concept.

If we are to develop successful and sustainable smart cities, there should be a focus on the use of the latest smart technology by its citizens. This will require an understanding of not only how people interact with technology and the degree to which they accept it and utilise it, but also the extent to which their beliefs and values support the use of the technology to achieve a sustainable, smart city.

Chapter 3: Smartness and Pro-environmental behaviour

3.1 Sustainable, Smart Cities

As noted in Chapter 2, within the broad smart city strategies there is a more specific focus on improving the efficiency and sustainability of electricity generation and consumption within the smart city (see Table 1, Chapter 2). Indeed, sustainability can be considered the normative goal which is being imposed onto the "smart" technological innovation trajectory (Seyfang & Smith, 2007). Through the ICT driven innovation of the electricity network, often termed smart grids, there is an opportunity for residential consumers to have a greater, participatory role in the management of the electricity demand and even supply. Consequently, smart grids have implications for current, normative electricity consumption behaviours and offers an example of a smart technology through which to explore smart citizens. The smart grid, its implications for citizens, and the challenges of acceptance are discussed below.

3.2 Smart Grids

Smart grids are described as being electricity networks that are enhanced by information communication technologies (ICTs) and are argued to be the solution to the current and near-future energy issues of rising electricity consumption, the increasing amount intermittent renewables in the grid, and the increasing amount of distributed generation (Ellis & Jollands, 2009; Warren, 2014). The smart grid is also important for enabling some of the envisioned smart city features outlined in Chapter 2, such as electric vehicle battery charging/storage (Christensen, Wells, & Cipcigan, 2012; Couillet, Perlaza, Tembine, &

Debbah, 2012), or greater penetration of micro-generation (Molderink, Bakker, Bosman, Hurink, & Smit, 2010; Sooriyabandara & Ekanayake, 2010)

Smart Grids are consistent with a move towards greater decentralisation of the electricity system and are consistent with the purported empowering ethos of smart cities, with smart grids enabling greater householder engagement, participation, and self-regulation (Verbong & Loorbach, 2012). This can be contrasted with centralisation scenarios, which could lead to a marginalised role of the householder, and network operators having a greater control over end user consumption (Balta-Ozkan et al., 2014; DEFRA, 2008). Key aspects of what Naus et al. (2014) term 'radical centralisation' and 'radical decentralisation' scenarios are shown Table 5. However, it is the participatory, socio-technical aspect of smart grids that is being increasingly recognised as deviating the most from traditional electricity networks (Goulden et al., 2014; Wolsink, 2012).

3.2.1 From passive to active: A shift in the role of the energy consumer

Table 5. Summary of polarised visions for smart grid developments.

Radical Centralisation	Radical Decentralisation
• Centralised demand side management. • Centralised "super grid". • Centralised generators. • Marginal role of householders. • Increased monitoring of consumers. • Greater control of end user consumption.	• Distributed Generation Micro Grids. • Interconnected micro-grids. • Largely self-governing generation. • Households increasingly self-sufficient and • Self-regulating.

Terms from: (DEFRA, 2008; Goulden, Bedwell, Rennick-Egglestone, Rodden, & Spence, 2014; Naus, Spaargaren, van Vliet, & van der Horst, 2014; Verbong, Beemsterboer, & Sengers, 2012; Wolsink, 2012).

Whilst the technical specificities of smart grids are debated, it is acknowledged that the increased participation of the users, and the opportunities for users (householders) to have a more active role within the electricity network is one of the most significant changes enabled by a smart grid transition (Verbong et al., 2012). Naus et al. (2014) argue that smart energy technologies are facilitating a shift from the traditional role of end-users as passive consumers to one in which they are "co-shapers" of the smart grid. This view is shared within the UK government with DECC describing its smart grid ambition as being to "empower individuals…to choose how they will play their part in reducing the UK's carbon emissions" (DECC, 2009 p. 7) and, as such, householders should be considered throughout the "incremental process" of making electricity grids smarter (DECC, 2009 p. 1). This also echoes the view of Harrison et al. (2010) that the citizen should be able to participate in the smart city to the extent that they are influential in its success or failure. Consequently, the smart grid, and requisite smart energy technologies, will become a key area through which citizens will participate in, and influence the smart city system.

One way in which householders are viewed as being enable to be more active in the electricity grid, and indeed how they will co-shape its performance, is through participating in residential Demand Side Management.

3.2.2 Demand side management

Traditionally, energy utilities have aimed to match their supply to the rising demand for energy (Torriti, Hassan, & Leach, 2010). Demand Side Management (DSM), however, reverses this process and focuses on how the demand for electricity can be made to match the available supply. There are several definitions of DSM, with slightly different foci and encapsulations (see Warren, 2014 for an overview). However, a comprehensive definition of DSM is provided by Warren (2014 p.943): "Demand-side management (DSM) refers to technologies, actions and programmes on the demand-side of energy metres that seek to manage or decrease energy consumption, in order to reduce total energy system expenditures or contribute to the achievement of policy objectives such as emissions reduction or balancing supply and demand". This may involve load shifting (alternatively known as 'demand response'). Load shifting is when consumers reduce consumption during times of high demand/low supply (peak reduction) and/or increase consumption during times of low demand/high supply (valley-filling). The intended result is less fluctuation in the demand for electricity, which allows for more predictable, and therefore more efficient supply.

In the UK, DSM has been stated as the main way in which the National Grid (the UK's distribution network operator) will balance the electricity system by 2030 (Ambrose, 2015). For the UK, in 2012, a reduction of ~1.2 - 4.4GW was predicted as being achievable through DSM under the existing and proposed demand response policy measures in the non-domestic sectors (Warren, 2014). In addition, from a 24 hour load profiling of 250 households in the UK, Palmer, Terry, and Kane (2013) ascertained that there is "considerable scope" (p.2) for load shifting in the residential sector, with the evening peak demand (6-7pm) being an average of three times higher than the baseload.

Due to load shifting requiring the electricity to be consumed at times which are beneficial to the grid, the success of load shifting (and DSM strategies) will require residential consumers to alter their behaviours and become more flexible consumers of electricity (Steg, 2008; Verbong et al., 2012). As such, the user is central to the purpose of the smart grid technologies and motivating consumer acceptance of change will be crucial.

3.2.3 Motivating change in energy consumption

It is argued that, when making energy choices, householders will be incentivised to engage with demand response and electricity conservation through economic incentives. The incentives come from the householders being able to pay for electricity at a price that reflects the time-varying production costs of the electricity, i.e. the wholesale price of electricity (Hirst & Kirby, 2001). Presently, across Europe it is common practice for most householders to be charged at a fixed, average price for the electricity that they consume. Therefore, the consumers neither reap the benefits of when the wholesale prices are low, nor suffer the drawbacks when the wholesale prices are high (Albadi & El-Saadany, 2008; Allcott, 2009; Ipakchi & Albuyeh, 2009; Lijesen, 2007). As a result, these fixed electricity tariffs provide no incentive for customer to contribute in making the system more efficient through participating in load shifting (Tiptipakorn & Lee, 2007).

A contrast to fixed price tariffs are flexible pricing tariffs, such as real time pricing (RTP; Mohsenian-Rad & Leon-Garcia, 2010). With RTP, the householder receives information hourly (for example) about the current cost of electricity. If the cost is high at that time (either due to peaking demand, low supply, or other factors), then the consumer will have the option to reduce their consumption in order to prevent themselves from using relatively expensive electricity. Likewise, if the price is relatively low, consumers will be able to consume more electricity at that time for less money. Through these price signals, the householder (it is argued) is motivated to either load shift, curtail (peak clipping) or increase (valley-filling) their consumption (Holland & Mansur, 2006).

3.2.3.1 Limitations of flexible pricing for changing behaviour

The flexible pricing models are all based on the economic assumption of the rational-actor (Strengers, 2014). The rational-actor assumption states that the householder will chose the behaviour that saves money or their other resources (e.g. time). Consequently, when conveying the benefits of DSM and smart energy technologies to consumers, cost saving potentials are frequently highlighted (Evans et al., 2013; Giordano et al., 2013). There is some evidence to support using economic incentives for DSM. For example, surveys have found that consumers would be willing to load shift in order to save money (Silva, Karnouskos, & Ilic, 2012) and the trials of time based price schemes have shown some reductions in peak demands (CER, 2011).

The relationship between monetary saving and intention to load shift, however, may be more complex than the rational-actor model assumes (Goulden et al., 2014). For example, a large survey of UK householders found that the greater the participants' concern about the affordability of their energy in the future, the less accepting the participants were of DSM. This was argued to be due to the participants mistrusting the potential for financial benefits from DSM (Spence, Demski, Butler, Parkhill, & Pidgeon, 2015). Furthermore, a focus-group study found that participants did not view the potential to make small savings as enough of an incentive to sacrifice their energy-based routines, convenience, or comfort (Goulden et al., 2014). Similarly, interviewees in a study by Hargreaves, Nye, and Burgess (2010) stated that they would require "significant financial incentives" (p. 6117) before they would alter certain energy practices and that small daily savings would not provide enough of a motive for them.

Being able to consume electricity without restriction is emerging as a higher priority in householders' consumption considerations. When considering load shifting, people tend to prioritise their convenience, their wellbeing, achieving their ideal home, and routinized behaviours above small monetary savings (e.g. Barnicoat & Danson, 2015; Bourgeois, Van Der Linden, Kortuem, Price, & Rimmer, 2014; Hargreaves et al., 2010). Considering that the monetary savings through RTP could be relatively small on an individual household basis (Larsen & Sønderberg Petersen, 2009; Strengers, 2010), the motivation for the householder to act ‘rationally’ may reduce as comfort and convenience are sought and small savings are disregarded or mistrusted (Goulden et al., 2014; Hargreaves et al., 2010).

The above studies suggest that monetary savings might not offer a strong incentive for load shifting in an RTP model, and there may be barriers to the acceptance of load shifting behaviours and technologies, additional motivators for householders to accept smart energy technologies and load shift may be required, such as an individual’s values.

3.2.3.2 Values as motivators for changing energy consumption

Values are argued to be a motivational constructs which represent broad goals and can apply across contexts and time (Bardi & Schwartz, 2003). Self-transcendent or altruistic values (i.e. a concern for more than the self or immediate social group) have been found to relate to pro-environmental behaviours (Schultz & Zelezny, 1999; Stern & Dietz, 1994; Thøgersen & Ölander, 2003). In order to develop the understanding of this relationship, Stern (2000) and Stern, Dietz, Abel, Guagnano, and Kalof (1999) developed the value-belief-norm model. They argued that biospheric, altruistic, and egoistic values predict ecological worldview, beliefs of the adverse consequences for valued objects, and perceived ability to reduce threat. These beliefs form the basis of an individual’s personal norms regarding pro-environmental action. These norms are then argued to motivates pro-environmental behaviours and support for pro-environmental action (e.g. Poortinga, Steg, & Vlek, 2004; Steg & Vlek, 2009).

Studies on the perceptions of load shifting have found that self-transcending and environmental values held by participants often motivated them to load shift. For example, Strengers (2010) found that when it came to “shifting” air conditioning usage in Australia in response to critical peaks, a feeling of social responsibility was cited as a key motivator by participants. Similarly, participants who were willing to reduce their consumption during critical peaks cited a non-rational, “common good factor” as their motivation. Other survey studies have found that often monetary and environmental values are both potential incentives. For example, it was found in a survey of householders in Hong Kong that the largest proportion of participants agreed that environmental concerns would motivate them to load shift, whilst saving money was the second largest motivator (Mah, van der Vleuten, Hills, & Tao, 2012). Additionally, a European survey found that participants would be willing to load shift for environmental reasons, although they would also expect some form of monetary incentive (Mert, Suschek-Berger, & Tritthart, 2008).

Goulden et al. (2014) suggest that participating in studies on real-time pricing will be of most interest to individuals who were already prepared to engage in load shifting behaviours, and are motivated by factors other than money, such as concerns for the environment. As such, some of the household savings in electricity seen in flexible pricing studies may not have been because participants were motivated by the opportunity to save money, as is often argued, but rather a self-selection bias towards participants with pro-environmental values.

Similar to the possibility of self-selecting, pro-environmental participants, Hargreaves et al. (2010) noted that several of their participants already possessed energy meters and were motivated to take part in a smart meter trial by a desire to learn more about their household energy use. To these participants, participating in the trial was “merely the next step in a longer journey of collecting information and monitoring their domestic energy consumption” (p. 6114). This sustainable “journey” has also been observed in other studies of smart energy technology users (Van Dam, Bakker, & Van Hal, 2010; Woodruff, Hasbrouck, & Augustin, 2008). Hargreaves et al. (2010) recognise that participants in their trial of smart meters and in home displays could be considered “early adopters” (pg. 6119) of the technology and, therefore those who were most interested in changing their energy behaviour and accepting new technologies compared to the majority of potential consumers.

3.3 CONCLUSIONS

The smart city strategies intend for there to be smart citizens. Being a smart citizen may take the form of using smart technology to participate in the goals of the smart city strategies. Therefore, understanding the socio-technical interactions between the user-citizens and the smart technology innovation will be important if smart technologies are to facilitate goals for sustainability (Paetz et al., 2012). In particular, understanding citizen values, norms and goals in relation to the acceptance of future smart technologies when there is an agenda (such as sustainability) imposed onto the user-citizen will help to inform the innovation of smart technology and to achieve the smart city strategies (Shilton, 2010; Valkenburg, 2012).

The citizen will be, in particular, critical to achieving smart grid purposes and so, by extension, the goals of a sustainable, smart city. The early literature on load shifting and smart energy technologies opens up the question of whether smart, sustainable city outcomes can be achieved without citizen possessing appropriate values. Indeed, even if the monetary incentives were perceived as enough to overcome the perceived inconvenience of technology use, monetary incentives offer only limited behaviour change. Therefore, campaigns which appeal to values may offer favourable motivators of behaviour change, particularly when the change is for the benefit of the wider, collective. As such, what will motivate citizens to participate in the development of smart, sustainable cities needs to be explored.

Chapter 4: Study 1

Interviewing UK City Stakeholders

4.1 INTRODUCTION

In response to the underdeveloped discussion of smart citizens and a growing recognition that there is a need for (a) citizens to be engaged with the technology and infrastructure associated with the smart city development (Lombardi et al., 2012); (b) for the smart cities to both foster and attract "smart citizens" (Hollands, 2008); and (c) for the values and beliefs of the individual smart citizen to be explored, Study 1 used interviews with UK city stakeholders. Interviews were selected for Study 1 because the available discussions of citizens in relation to the smart city were found to be limited in the extant literature (see Chapter 2). Therefore, it was felt that the perspective of experienced stakeholders in the field of city development, management, policy, and technology could be fruitfully explored in order to identify the direction of UK city developments, and the perceived role of citizens in the smart city strategies. It was intended that this would contribute to the academic and policy related discussions of smart citizens and inform the focus of the following studies for this thesis. In line with this intention, the perspectives of the UK city stakeholders were then discussed through the lens of prominent psychological theory.

4.2 METHOD

Study 1 received ethical approval from the University of Sheffield's Department of Psychology Ethics Committee.

4.2.1 The Approach: Elite interviews

The intended interviewees (i.e. UK city stakeholders) were people who have influence and/or possess particular expertise and so can be considered “elite” in their field (Burnham, Gilland, Grant, & Layton-Henry, 2004; Lilleker, 2003). As such, an elite interview methodology (Burnham et al., 2004; Morris, 2009) was adopted to explore UK city stakeholders’ perspectives of the smart city and smart citizens. Elites are desirable for research as they have specialist insight and knowledge into their field. By interviewing multiple elites, it is intended that points of convergence (and divergence) in their perspectives can be identified and inform the researcher of the current thinking in the field. As such this approach is ideal when developing theory or exploring a new topic as it can point to avenues for future research, or gain unique insight into a topic (Boyce & Neale, 2006).

4.2.2 Participants and recruitment

The elite interviewees in the current study were a purposive sample chosen for their experience, expertise, and/or ability to influence city development and policy in the UK. Potential interviewees were identified through an internet search for UK smart city developments and by attending conferences on related topics (e.g. “The National Future Cities Conference 2013”). Contact was then made with the potential interviewees via email to invite them to take part. It was stressed that it was their personal views that were of interest to the research and not those of the company. The desire for the interviewees’ personal views was stressed to try and ensure that the interviewees did not use formulated answers that only repeated their company’s/institute’s views on the topic. Using formulaic answers may have limited the interviewees’ in terms of how much they would draw on their own, unique experience and expertise to answer the questions. To further to ensure interviewees’ ability to express their own opinions, they were informed their responses would be anonymous when transcribed and used in any reports. It was offered that a report could be shared once the study was complete.

In total, sixteen UK city stakeholders were contacted via email and invited to be interviewed as part of a ‘university research project into future cities and the role of citizens’. Of these eleven accepted from a mix of UK public and private sector backgrounds. See Table

Table 6. List of the interviewees’ roles in Study 1

Role	Number
Head of Sustainable Development for the city council.	2
Future city coordinator for the city council.	3
CEO for a UK based community interest company focused on smart technology.	1
CEO for a not-for-profit organisation which advises public and private sectors.	1
Director for an independent group of technical specialists	1
The coordinator of a UK national environmental organisation.	1
The head of sustainability for a UK executive non-departmental public body	1
Academic researcher of city development	1

6 for the list of their roles. All participants had experience relating to sustainable and technological developments within cities and of working on projects and policies that related to the implementation smart initiatives into cities.

4.2.3 Interview Question Development and Procedure

The interviews were semi-structured and open-ended as this allows for participants to fully express their views and opinions (Gall, Borg, & Gall, 1996). The interviewer used prompts sparingly to encourage interviewees to form their own ideas and to avoid leading the interviewees' responses. The questions were developed to examine interviewees about their perceptions of the challenges facing current cities, directions and possibilities of future (smart) city developments, and the roles for /expectations placed upon citizens (see Table 7). The questions were themed on smart city developments and the interactions between technology and citizens as these were identified as a key focus of smart cities in the literature review (Chapter 2). The questions were asked identically to each participant and were framed to allow the participant to openly respond.

Interviews were conducted either face-to-face at the interviewee's place of work or by telephone and were completed in 45-90 minutes. All interviews were audio-recorded and subsequently transcribed. Interviewees were fully informed of the procedure and were allowed to withdraw at any time. All interviewees provided informed consent to participate. Interviews were conducted by me between December 2012 and March 2013.

Table 7. Questions used during interviews of Study 1

Cities currently:

1) Would you say that [their city/UK cities] is/are currently facing challenges related to energy use and the environment?

How are cities developing?

2) What, if anything, does the concept of sustainability in a city mean to you?

3) What role, if any, do you think new technologies will have in future cities?

4) *If Smart cities haven't been mentioned by this point*- Have you heard of the concept of "smart cities"?

If yes- What do you understand by this term? What, in your view, makes a smart city smart?

5) Are there drivers and barriers to achieving smart cities?

Role of citizens

6) What role, if any, do you expect there to be for citizens in facilitating the goals of future cities?

7) In your view, how aware are general citizens are about future city developments, either ones for sustainability or smartness?

9) *If talked about citizens being related to the success of future city goals*- How aware of their role in the success of these developments do you think citizens are?

Expectations of future citizens:

10) If not already mentioned: Do you think future cities will require citizens to change? And if so, in what way?

11) Conceptualisations of future cities tend to talk about their citizens using terms like 'active, empowered, engaged and smart': are these phrases you have heard and what do they mean to you?

N.B. Question themes are emboldened.

4.2.4 Interview Analysis

Transcribed interviews were anonymised and analysed using an inductive thematic analysis (TA) approach (Braun & Clarke, 2006). With inductive TA the data has primacy and the theme are developed directly from the data. In this sense, theory is developed from the data rather than applied to it. Therefore, as the smart citizen concept was not sufficiently developed, the inductive TA methodology allowed for exploration of the interview data and identification of new aspects of the smart citizen, which could be explored in future studies.

Using the qualitative data managing software, NVivo, I performed the initial coding of the transcripts. A coding manual was produced (see Appendix A), which was then provided to an independent, blind second coder. The second coder used the coding manual to code 3 (~25%) of the interview transcripts. Disagreements between the coding of the first and second coders were then discussed and the coding adjusted until a satisfactory level of agreement was reached across all codes (this was defined as >70% agreement; Kappa = >0.5: see Sim & Wright, 2005 for a discussion of the Cohen's Kappa statistic). Any agreed changes were then applied to the remaining transcripts. As per the TA method (Braun & Clarke, 2006), the codes were then collated and reviewed by the first author to identify the central themes arising from the data. On the basis of the analysis, four central themes of 1) Citizen Exclusion and Inclusion, 2) Smart Technology and Citizens, 3) Collective Responsibility, and 4) Individual Differences, were defined. These will now be described.

4.3 RESULTS

4.3.1 Citizen Exclusion and Inclusion

4.3.1.1 Exclusion of Citizens

Interviewees felt that currently citizens are often excluded (or not *included*) within city governance or development. Interviewees commented on the current top-down, technocentric, nature of the smart city concepts and outlined a need for more involvement and consideration of citizens in decision-making:

> *"Smart city agenda is being run by big companies and by city governments and you know, there is clearly, as with many of these things, sometimes limited user involvement" [M1].*

This commentary is to be expected. To date, there has been a heavily top-down focus to smart city development, in the sense that the parameters of the smart city concept have been largely defined by technology developers, such as IBM and Cisco Systems, who seek to sell the concept (and requisite ICT solutions) to governments and to city leaders (Washburn & Sindhu, 2010). Only latterly have academic discussions of the smart city increased, leading to a wider debate, discussion, and research into what it should mean for a city to be smart and how to make cities smarter (Bakıcı, Almirall, & Wareham, 2013; Lombardi et al., 2012).

The interviewees discussed the perceived imbalance in top-down vs. bottom-up approaches to decision-making for future cities. In particular, they recognised that the principal 'users' of smart city systems, would be the citizens, whom the current models and conceptualisations were neither considering nor involving:

"I guess ultimately a city isn't smart without its citizens being engaged in that, I guess when you talk about how you empower citizens then you have to deliver your smart city vision in a way that does empower them…if it's all top-down, I'm not quite sure how it empowers them" [M4]

The interviewees' perception of a predominant, top-down approach to the development of smart cities contradicts the growing smart city literature (as discussed in Chapter 2), which intends for smart city developments to be empowering for citizens (e.g. Naphade et al., 2011). Indeed, a perceived need for greater bottom-up approaches within smart city developments reflects literature on new governance (Bingham, Nabatchi, & O'Leary, 2005), and reiterates the need for citizen empowerment and participation (Hollands, 2008).

4.3.1.2 Aware and Demanding Citizens

Whilst interviewees were advocates of greater involvement of UK citizens in the decisions relating to the development of smart cities (i.e. user-centred, participatory design), there was a simultaneous recognition that, at present, the likelihood of engagement from the UK publics was very low. The perceived low levels of awareness and engagement amongst citizens was viewed as a barrier to the citizens' inclusion within city developments:

"The really key issue is, and it's an awful phrase, is 'Joe-public's' understanding of the issue. The level of background debate and the general knowledge of the issues is very, very low and that causes problems, it creates inertia, so our ability to move forward as a city is hampered by that" [M6]

This is pertinent as a failure of citizens to engage with smart city agendas could reduce the likelihood of these citizens (a) adopting the empowerment opportunities and/or goals of city;

and (b) embracing the requisite technological and behavioural change implied by the city. In turn, the lack of engagement of citizens and their lack of awareness was seen as inhibiting the development of the city as it prevents the city leaders being able to debate the issues with the citizens.

Interviewees suggested that by increasing citizens' knowledge of sustainability and smart developments in terms of what the city's goal are, how they are measured, and how they are achieved, then this would help to unite citizens in shared goals:

"Once citizens become more aware of what are the simple metrics and the simple goals of the future city…that'll help the narrative, you know what I mean?…we've got a target to work towards, then we can all buy into it together" [M2]

Whilst this argument is partially a knowledge deficit argument — i.e. if we just give them more knowledge about the city's goals, then people will start to contribute towards achieving them (an approach which can be problematic or ineffective for change; Brunk, 2006; Devine-Wright, 2005; Hansen, Holm, Frewer, Robinson, & Sandøe, 2003) — it actually goes further as it recognises the importance of individuals sharing the city goals and be willing to work towards them.

Interviewees felt that an outcome of citizens being more informed and engaged with the goals of their city and its development would also be that the citizens become more demanding of their city leaders. As such, city developments could become increasingly demand led:

"What will citizens demand of cities?" [F4]

This suggests that there is a perceived opportunity to switch the direction of influence from new city infrastructures (digital or otherwise) perhaps being imposed onto citizens through top-down strategies, to having citizens asking for the smart infrastructure and influencing the development. Indeed, interviewees' felt that citizens would want city leaders to be seeking and using the latest technology to enhance the services in the city.

4.3.1.3 Inclusion of Citizens

The communication channels need to exist for citizens to be able to participate and `the decision makers in the local authorities need to actually factor in the citizens' views in order for this participation to have mean, and for citizens to be empowered:

> *"The empowerment has to be complemented by actions that demonstrate to citizens that whoever is on the other side, does care about what citizens have to say" [F11].*

Relatedly, Angelidou (2014) argues that if smart city developments are to include citizens it will require collaboration among community and private actors. Methods of collaborative engagement currently employed by governments, local governments and technology developers involve such bottom up approaches as open innovation, community innovation and crowd sourcing (Paskaleva, 2011; Sauer, 2012; Schuurman, Baccarne, De Marez, & Mechant, 2012). Although it has been argued that, within the European Union, the policy to support these approaches are not yet in place (Paskaleva, 2011), these community level approaches offer avenues through which citizens can participate and be included in their city's development.

In sum, the Citizen Exclusion and Inclusion was developed from interviewees' recognition of a) the top down nature of smart city strategies, b) how the top down strategies conflict with the desire for empowered citizens, and c) citizen awareness and engagement in city development is currently low, which creates barriers to development. More aware and demanding citizens need to be complemented by development strategies that empower the citizen.

4.3.2 Smart Technology and Citizens

4.3.2.1 Technological Empowerment

Reflecting the smart city conceptualisations (discussed in Chapter 2), the use of technological innovation was at the forefront of the UK city stakeholders' perceptions of city development and were seen as offering many benefits to sustainable city management and citizens (see also: Toppeta, 2010). For example, it was suggested that technology will facilitate a greater participation of citizens within the city governance:

> *"As people become more enlightened of what they want out of their city, I think they can be at the heart of it and I think technology will be at the heart of that as people become more and more connected" [M2].*

The idea of technology providing citizens with greater opportunities for participation is in line with the strategy behind e-government and is discussed as a characteristic of a smart city (Anthopoulos & Fitsilis, 2010; Chourabi et al., 2012; Giffinger et al., 2007; Hollands, 2008).

4.3.2.2 Technological Disempowerment

Whilst there was a discussion by interviewees of the potential benefits of the smart technologies for the citizens in terms of governance, interviewees highlighted that there is a tension between automatization and disruption. On the one hand, the automatization of the smart city services may be beneficial (see Table 3 of Chapter 2 for further examples of potential benefits). On the other hand, automatization may, at best, encourage citizens to be more passive and, at worst, restrict citizen choice and agency:

"You could see a kind of, smart city, one where all this data is collected by companies and city authorities and basically algorithms, which are based on past behaviours and preferences, and existing conceptions of efficiency decide everything for us. And in some ways, people will say "that's great, you know, I'm not going to have to make choices, things are joining up and things are flowing smoothly". The danger is that, first of all, algorithms tend behave based on past behaviours and preferences…and secondly, you know, that sounds like it would be profoundly disempowering for the citizen [M1]"

Therefore, whilst the use of technology may have benefits for participatory governance, other (or the same) forms of technology may have implications for other important aspects of being a citizen, e.g. having agency and choice. The use of smart technologies may disempower the same citizens that city leaders wish to empower.

4.3.2.3 Smart technology and behaviour change

It could be argued that if citizens forgo personal choice and interact with their cities in a more passive way (i.e. not participate, and simply do as they are told), then this could help to facilitate the broader goals of the city. However, not only does this vision conflict with the academic conceptualisation of what a 'smart citizen' should be (e.g. active and empowered), but our interviewees noted that many smart city and technological goals, particularly those for sustainability, will require an active and engaged citizen:

"I would say I don't want technology to be a replacement of human thinking… I think technology should be disruptive, maybe we should be very aware that the technology is there because that will make us think about how we behave and then maybe we will change … So we want a technology which will engage the citizen rather than makes them become completely passive" [F11].

In line with their discussion of including citizens within the development of smart cities, interviewees viewed having active, empowered citizens as being preferable to having passive and disempowered citizens. This is a view of using smart technology to disrupt behaviours or encourage the user to think differently about their behaviours (Verplanken & Wood, 2006). This may still be for the benefit of the collective, however, this interviewee was distinguishing between the technologies doing something on behalf of the user, with no user input, versus the technology prompting the user to change their own behaviour.

Using technologies to disrupt behaviour and encourage reflection on unsustainable behaviours relates to the argument that the introduction of smart technologies to a city may, alone, not be enough to cause behavioural change amongst citizens (Coe, Paquet, & Roy, 2001; Lindskog, 2004; Nam & Pardo, 2011a, 2011b). There will be a need to engage the citizens in the use of the technologies, as suggested by the following interviewee:

"Technology is only useful if you've really got engagement of people at all levels, whether they're in employment, in organisations or institutions or whether they're residents out there or visitors or whatever, where there's a real, consistent behaviour change, which is facilitated by the technology, it's not caused the technology, it's caused by people changing their minds" [M7].

This recognition that engagement is required in order for the technology to be effective or useful supports the emerging literature on engaging citizens with new technologies and conversely, the impact technologies can have on citizen engagement (Bimber, 2000; Devine-Wright, 2007; Firmstone & Coleman, 2015; Lindskog, 2004).

In sum, the theme of Smart Technology and Citizens, was developed from interviewees' recognition that a) technology has an important role within the development of the city, but b) the technologies should empower, rather than disempower, citizens and that c) a tension may exist between technologies which disrupt behaviour and technologies that automate the behaviour. Technological solutions that disrupt unhelpful behaviours were preferred to technological solutions that automate behaviours. Equally, technological solutions that empower citizens were preferred to those that may disempower citizens.

4.3.3 Collective Responsibility

An aspect that was seen as fundamental to increasing citizen inclusion within smart city developments was the citizens' values and identity. It was felt that there would need to be a shift from the current individualism in the UK to more of a collectivist identity in order to reduce selfish behaviours, which were seen as being detrimental to the achievement of smart, sustainable cities:

> *"I think the role of citizens needs to change, I think there needs to be greater civic responsibility taken, that comes down to a sense of identity and again it comes down the balance of individualism versus collectivism" [M8].*

This suggests that in order for citizens to be successfully included within the smart, sustainable city development they may have to possess characteristics that motivate them to work for the benefit of the collective, such as environmental citizenship (Stern, 2000), place attachment (Manzo & Perkins, 2006), or sense of community (Chavis & Wandersman, 1990).

A greater sense of collective, may mean that the individual is more willing to act in a way which is beneficial to the collective at no benefit, or even cost, to themselves. This was seen as being a necessary process of managing a city:

"Yeah, I think, individuals need to change, communities need to evolve and change and as a consequence the city as a collective will change. And if we get it right, when you look at things in the city or at a city region scale, the decisions that the local authority takes are often to try and balance the needs of the many against the needs of the few; individual behaviour is just that, it doesn't always work in the best interests of the city or the neighbourhood, so technology can provide important ways in which some of that joining up and incentivising the right behaviours so that you don't actually have the individual needs in conflict with the needs of a bigger scale Geography" [M7]

The interviewee was optimistic about using smart technologies and the associated greater information and connectivity, to help balance the needs of individuals with the needs of the collective within the city. In particular, he felt that smart technologies would have the potential to enable local authorities to guide individual citizens to act in a way that is beneficial to the collective, such as by incentivising prosocial choices.

The idea of using smart technologies to guide individuals into making prosocial choices touches again on the issues of disempowering citizens (through technology) in order to benefit the greater good. It could be argued that restricting individual choice (i.e. individual disempowerment) for the greater good of the city (i.e. smart city) is a smart decision for city managers; a positive outcome of pervasive or ubiquitous computing, such as with so called "calm technologies" (Brown, 2012; Krüger, Schmidt, & Müller, 2010; Weiser, 1991). Citizens, who feel a greater responsibility for the collective, would perhaps be more willing to be disempowered in such a way.

To recapitulate, the theme of Collective Responsibility, captured interviewees' discussion of the changing role of citizens and that there needs to be a) a greater sense of collective responsibility and b) a willingness to act for the benefit of the collective.

4.3.4 Individual Differences

Despite the interviewees indicating a need for greater inclusion, participation, and empowerment, and the suggestion of technology use, and collective values, and responsibility, they recognised that citizens' perceptions of the smart technologies will be crucial to citizens feeling either empowered (to have greater control over their lives) or disempowered (by having control taken away):

"The same technology could be seen as this fabulous tool that cuts my costs and the same technology that is presented wrongly and set-up wrongly, could be 'there's this spy looking over my shoulder that stops me living my life the way I want to'" [M1].

This point is pertinent bearing in mind the impact that public perception of new technology is known to have upon their uptake and use by citizens. Indeed, public perceptions of technologies are known to be subject to a large number of influences. For instance, the perceived ease of use and perceived usefulness of a technology (Turner, Kitchenham, Brereton, Charters, & Budgen, 2010); or the perceived subjective norms, and the perceived risks associated with the technology (Barham, Chavas, Fitz, Salas, & Schechter, 2014; W. R. King & He, 2006; Schepers & Wetzels, 2007).

Interviewees also recognised that there are likely to be individual differences in citizens' motivations for engaging with technologies and/or participating in the city:

"I think so and also I think people participate in different projects for different reasons, so, some will do it for an environmental reason and others will do it purely because they want to save money, or, yeah, or for yeah other, they might be interested in technology" [F4]

This presents a challenge to the engagement of citizens as different strategies to promote engagement may be required depending on the citizen's motivation. It also serves to reiterate the necessity of having a greater understanding of smart citizen as there are likely to be complexities that previous and current studies investigating smart citizens (as discussed in Chapter 2) have yet to discuss or explore.

In sum, the Individual Differences theme, demonstrates interviewees' awareness that a) the acceptance of the smart city by citizens' will rely on the individual citizens' perceiving the technology positively and b) there will be individual differences motivating citizen's acceptance or rejection of the smart technologies.

4.4 DISCUSSION

Study 1 aimed to identify the perceptions of UK city stakeholders regarding the development of smart cities and the role of the citizen within them. This was to progress the discussion of smart citizens by identifying the stakeholders' primary considerations for citizens in increasingly technocentric city strategies. The interviewees' discussions reflected some of the issues within the existing smart city literature (see Chapter 2). For example, the predominance of top-down approaches in smart city strategies (e.g. Hollands, 2008) and the increasing focus on using ICT within city strategies for sustainability (e.g. Harrison et al., 2010; Naphade et al., 2011). Interviewees also shared the view that smart technologies will change how cities are managed and how citizens interact with the city and the city leaders (e.g. Caragliu et al., 2011; Washburn & Sindhu, 2010) and that the success of smart technologies will require engagement with and from the citizens (Coe et al., 2001; Lindskog, 2004; Nam & Pardo, 2011a, 2011b). However, Interviewees' also highlighted some new concerns.

The interviewees discussed some concerns regarding smart citizens that are not identified in the literature. For example, they saw a tension between using smart technologies to engage and empower citizens on the one hand, and smart technologies not engaging citizens and disempowering them, on the other. The interviewees felt that smart technologies should be empowering citizens and including them more within the development processes of the city. Interviewees' also felt that citizens would need to be more aware of the goals of the smart city, take greater responsibility for achieving the goals, and act in a way which is beneficial to the collective. These aspects of smart cities and citizens will now be discussed in terms of the attitudes and values that may be important for individual citizens to possess in order to be a smart citizen in light of the interviews.

The top-down nature of smart city strategies and city developments could, in part, the result of the smart city requiring technological expertise. Whilst urban development and policy requires expertise in and of itself, the rapid development of smart technologies and the process of embedding these technologies within the infrastructure of cities requires extra expertise. Consequently, city leaders develop a technocratic orientation and increasingly rely on the advisement of technology experts in how the city can be developed, to the potential exclusion of alternative considerations (Friedman, 2014). In this sense, the smart city concept is a self-fulfilling prophecy with the developers of smart technologies prophesising greater technology use in cities and city leaders subsequently pursuing these prophesises by seeking technological solutions from the "prophetic" developers. This process is in contradiction to the engaged and participatory citizens that are idealised within the smart city literature (see

Chapter 2) and by the interviewees. Indeed, the suggested lack of awareness and engagement from the public to date could be symptomatic of the technocratic, top-down nature of the decision-making process. As such, there needs to be re-orientation within smart city strategies so that they are citizen-centric.

This re-orientation may come through promoting the goals of the smart city in order to increase the citizens' awareness of the goals for the city and share the responsibility of achieving them with the citizens. Through the sharing of goals and responsibility, the interviewees suggested that the goals of the smart, sustainable city could be achieved more effectively. These views relate to the rhetoric of empowered, active, and participatory citizens that is used within the literature to describe smart citizens (e.g. Chourabi et al., 2012; Streitz, 2011). However, the discussion by the interviewees now enables these characteristics to be developed further. For instance, within his psychological empowerment concept, Menon (1999) proposes that individuals achieve a cognitive state of empowerment when they have internalised a shared goal, perceived themselves as having influence over the outcome, and perceived themselves as having the competence to accomplish the goal. Equally, within other theories of psychological empowerment, the importance of sharing a goal (Zimmerman, 1995) and finding meaning in that goal (Cattaneo & Chapman, 2010; Spreitzer, 1996) are emphasised for achieving psychological empowerment. Therefore, citizens sharing the smart city goals may be an important aspect of achieving empowered citizens, who in turn participate in the goals of the smart, sustainable city.

Being empowered to participate requires that the necessary communication channels, engagement, and policy are in place between the individual and the city leaders, such that the individual is actually able to participate in the governance of the city. It also means that individuals need to have the ability and freedom to act in their community, as well as have influence within their community (Ohmer, 2007). As such, the participatory initiatives, infrastructure, policies, and governance processes are the facilitators of empowering citizens to participate (Bingham et al., 2005; Fischer, 2012). However, as outlined above, empowerment, can also be discussed as a cognitive state, i.e. psychological empowerment (Cattaneo & Chapman, 2010; Menon, 2001; Zimmerman, 2000). From this perspective, the critical aspect of empowerment is that the individual perceives themselves as having power. Without psychological empowerment, individuals are unlikely to participate, even if the necessary facilitators are in place (Zimmerman & Rappaport, 1988). Empowerment, therefore, is both a process of governance and a cognitive state. However, as the aim of this research was to explore the smart citizen at the level of the individual, it was empowerment as a cognitive state (as opposed to a process of governance) that was explored further in Study 2.

Engaging citizens in the goals of the city could be an important step in achieving the psychological empowerment of citizens. Being inspired by a shared goal is an important aspect of psychological empowerment, as a shared goal is argued to empower and motivate an individual to contribute towards achieving the collective goal (Arciniega & Menon, 2013; Menon, 1999, 2001; Shamir, House, & Arthur, 1993). Accordingly, achieving greater citizen engagement and participation is more than citizens becoming aware of the goals for the city, it is about citizens internalising the goals, sharing them with a wider community, or society, and as a result being motivated to achieve them (Deci & Ryan, 2000; Menon, 1999, 2001). Engaging citizens in the goals of the smart city, however, may be challenging. The interviewees, for instance, felt that citizens currently have low levels of awareness about city developments. From a governance perspective, smart city leaders could use public campaigns to increase awareness, such as visualisation of urban data in the cities (e.g. Moere & Hill, 2012). From an individual perspective, however, citizens may need to see themselves as responsible for the goal before they act.

An important aspect of taking greater responsibility is feeling capable of influencing the outcome. For instance, environmental citizenship is regarded as: "the capacity of people around the world to inhabit a shared imagined community where global issues … are, first of all, visible in their interconnectedness, and secondly, in part as a consequence of this experience of sharedness, amenable to common regulation" (Luque, 2005; p.212). As such, being an environmental citizen is argued to be one who perceives themselves as being both responsible for and capable of environmental protection. This combination is argued to be necessary for people to be active and engaged with global and local issues (Dobson, 2007; Hawthorne & Alabaster, 1999; Hobson, 2013). Therefore, environmental citizenship is both the knowledge of an issue and the perceived ability to act on that knowledge (Bell, 2005; Stern, 2000). These characteristics complement the characteristics of the ideal smart citizens identified by interviewees.

To foster greater responsibility and empowerment, it will important for city leaders and technology developers to consider how they approach the smart city development in a way that promotes citizens' participation. For instance, in organisational psychology, the role of transformational leadership is argued to be critical to shifting individuals' perspectives from their own goals, to the group's goals i.e. to go beyond their self-interest (Effelsberg, Solga, & Gurt, 2014; Shamir et al., 1993). This role for transformational leadership can be applied to local authorities, with smart city leaders communicating the goals and strategies of the smart city to the citizens. This would also serve to raise the perceived low levels of awareness amongst the citizens and could promote citizens to think about the collective goals of the city or their community.

Beyond governance of the smart city, the use of smart technologies themselves may influence citizens' empowerment. For instance, the interviewees perceived a tension in the role the smart technologies may have in empowering citizens. On the one hand, smart technologies may afford citizens opportunities for greater participation, and (actual and/or perceived) control over their lives, homes and city (empowering them). On the other hand, different smart technologies (or even the same technology perceived differently) may reduce citizens' (actual and/or perceived) ability to participate and have control over their lives (disempowering them). There is currently limited research on the interaction between smart technologies, empowerment, and perceived control. However, a recent study found that participants' who received psychologically empowering messages (which targeted self-efficacy and causal importance) used a mobile phone app to report local issues to their council more frequently than participants who only received thank you messages (Gonçalves et al., 2013). Greater psychological empowerment has also been associated with greater intention to participate in electronic voting (Alathur et al., 2011). In the case of both behaviours, greater psychological empowerment was associated with a greater likelihood of engaging with and using the technology in an active and participatory way. Therefore, perceived control and empowerment may influence citizens' smart technology acceptance and utilisation (Venkatesh & Davis, 2000) and the relationship should be explored further.

It is perhaps the empowering aspect of smart technologies that define the smart technologies as being distinct from non-smart technologies. It is envisioned that smart technologies will facilitate a greater citizen engagement with the city, with the governance of the city, and with each other (Lombardi et al., 2012; Streitz, 2011). For example, with e-government (Anthopoulos & Fitsilis, 2010), or even in the load management of the electricity grid (Gungor et al., 2013; Hargreaves, Nye, & Burgess, 2013), smart technologies have the potential to increase citizen participation in aspects of the city that has traditionally been the responsibility of national or private companies or government (Wamsler & Brink, 2014). The provision of information about energy use (Hargreaves et al., 2010), water usage (Willis, Stewart, Panuwatwanich, Jones, & Kyriakides, 2010), or public transport (Farkas et al., 2014) in real time, for example, is intended to include citizens within the management of the city in terms of the energy consumption, air pollution, and traffic congestion (Kitchin, 2014). This is both as individuals in their homes, as community members, and as consumers of the city's resources and users of its infrastructure.

In contrast to empowerment leading to citizens to participate more through technologies (or vice versa), technologies may disempower citizens through the automatisation of behaviours. For instance, whilst there are uses of smart technology to help facilitate beneficial behaviour changes, there is the danger that technology will make citizens passive, which in turn, may disempower them. For instance, pro-environmental behaviours were found to reduce if the behaviour (such as turning off the lights) was expected to become automated by a technology (Murtagh, Gatersleben, Cowen, & Uzzell, 2015). As such, technology has the potential to alter how citizens engage with the city. If the technology developed for use in the city (or home) is focused on automatisation, this may undermine citizens own feelings of responsibility to act towards the city's goals. The citizen may feel that they do not need to change their behaviour as their smart environment is managing everything on their behalf and may discourage them from seeking power.

4.4.1 Limitations

The author's note that the smart city concept is being applied internationally and the interviewees in the present study were based in the UK and as such, their discussion focused largely on UK considerations. However, it is felt that the discussions were broad enough to allow application to wider, developing societies. Future work may seek to analyse cross-cultural differences in smart citizens and in how smart city leaders approach the engagement and inclusion of their citizens.

Whilst elites are desirable for research as they have specialist insight and knowledge, there are particular challenges associated with interviewing them. For example, unlike in non-elite interviews, in elite interviews the interviewees are the experts. Consequently, they may be more likely to withhold their honest answer for fear of reputational damage (Berry, 2002), and there may be topics which they are not allowed to discuss or do not wish to discuss (Mikecz, 2012). As noted in the Method section, steps were taken to encourage open answers from the interviewees.

An additional challenge can be accessing the elite participants. Individuals with influence or expertise are likely to have certain barriers in order to restrict contact from general public members (Laurila, 1997), such as support staff who screen their communications (Hertz & Imber, 1993). This is reinforced by the likelihood that they will not have publically available details for direct contact, meaning general contact details for their company have to be used. In the present study, it was time consuming making contact with the elites, waiting for a response and then successfully arranging an interview date. This, however, is common in elite interviewing (Shenton & Hayter, 2004). Therefore, whilst the study only had an N = 11, smaller sample sizes are common in elite interviewing (Shenton & Hayter, 2004).

4.4.2 Future Research

This study sought to relate discussions of the smart citizen to psychological theory. Therefore, psychological empowerment (Menon, 1999, 2001) along with environmental citizenship (Stern, 2000) are two factors which were identified as important for achieving more participatory citizens. To explore the importance of psychological empowerment and environmental citizenship further, these factors could be operationalised and quantitatively explored. In particular, they could be used to explore the acceptance and use of smart technologies, as smart technologies will are a fundamental aspect of smart city strategies. Indeed, citizens using smart technologies will be necessary to achieve many of the smart city goals, particularly those for sustainability (Kramers et al., 2014). As such, Study 2 explored the acceptance of smart energy technologies using psychological empowerment and environmental citizenship.

It could be of interest to explore the interrelation between citizens and city developments. Interviewees perceived citizens as having low levels of awareness for smart city developments. This low level of awareness was seen as being a barrier to developments as it slows processes down. As noted, cities with more progressive sustainability programs had more participatory citizens (Portney & Berry, 2010), and interviewees felt that citizens should be demanding more from city leaders. Studies exploring the impact of citizen participation on city developments may provide further insights into the factors which enable such participation e.g. from the governance perspective and factors which motivate citizens to participate e.g. from an empowerment or citizenship perspective. This would be particularly interesting to explore in terms of how technology, such as e-government, has impacted on this (e.g. Momeni, Shamskooshki, & Javadian, 2011). This might allow for further exploration of the potential for smart technologies to empower or disempower citizens.

4.4.3 Conclusions

Therefore, the interviewees' provided both a confirmation of the visions and critiques of the smart city concept and identified new potential directions for achieving smart citizens. The interviewees held a positive attitude towards using technology to benefit the city and citizens, but recognised that the use of smart technology needed to be for citizen engagement and empowerment. Empowerment was considered in this discussion as psychological empowerment (Menon, 1999). Psychological empowerment incorporates the desire for citizens to share the goals of the smart city, have influence over the developments, and perceive themselves as competent enough to utilise smart technologies. In addition, taking responsibility and acting for the greater good was considered in terms of environmental citizenship. Environmental citizenship describes a citizen who is aware of issues related to the environment and feels a responsibility to act on the awareness (Dobson, 2007). Therefore, these concepts can be used to begin operationalising some of the smart citizen concepts and explore their importance for smart technology acceptance.

Overall, Study 1 (in conjunction with the literature review) suggested that citizens remain important rhetorical devices for city leaders, but there is little understanding of the citizen at the individual level of technology acceptance. As found in the literature review (Chapter 2), the common feature of many of the anticipated technological benefits of smart cities is that they rely on changes in the behaviour of the citizens (Goulden et al., 2014). This was reiterated by the interviewees of Study 1 who felt that the implementation of smart city strategies would require citizens to participate and share the goals. The importance of these characteristics for the development of the smart city was explored in Study 2 through the investigation of householder acceptance of smart technologies.

Chapter 5: Studies 2a and 2b

Acceptance of technologies for energy reduction and load shifting

5.1 INTRODUCTION

As considered in Chapter 2, it is possible that some aspects of the smart city can be rolled out with only limited engagement from citizens. However, it is increasingly recognised within the literature and by the interviewees of Study 1, that for the full potential of the smart city to be achieved, citizens may need to be actively enrolled and engaged in the smart city network (Caragliu & Del Bo, 2012; Dobson, 2007; Harrison & Donnelly, 2011). This is because for some smart technologies, there will be a human factor in achieving the optimal outcome, e.g. smart energy technologies (Goulden et al., 2014).

Engagement processes may include organisations and institutions involving citizens in policy-forming and decision-making activities (Rowe & Frewer, 2005). At the same time, being an engaged citizen (i.e. engaged citizenship) is argued to be characterised by citizens involving themselves in direct political activities, such as peaceful protests or boycotting of businesses (Dalton, 2015; McBeth, Lybecker, & Garner, 2010). However, citizen engagement with the debates of smart city developments will manifest itself in different ways and have different outcomes. For instance, on the one hand, greater engagement of the public further ‘upstream’ in the design stages of smart technologies may reduce public concerns and lead to greater acceptance (Bussu, 2014; Sanders & Stappers, 2008). On the other hand, there could be occasions when the process of becoming engaged leads individuals to voice their oppositional views or reject a development they may have previously accepted (or at least, not opposed) had they not been engaged with the development (Irvin & Stansbury, 2004).

The challenge is that engaged citizens are likely to take into account different considerations surrounding the technologies and have different motivations for becoming engaged. Crucially, they may draw different conclusions about whether they choose to accept the development or not (Irvin & Stansbury, 2004).

Engaging citizens in smart city developments, therefore, could be a double edged sword; it may help to raise awareness of the importance of the technology, but it also may make people aware of potential drawbacks or voice opposition (Irvin & Stansbury, 2004). Understanding the individual factors that influence individuals' acceptance of smart technologies will, therefore, be important in ensuring that the most influential factors are addressed during engagement processes. For instance, as noted in Chapter 3, focusing on monetary savings to engage households in smart energy technologies, may not have a large influence on acceptance (Goulden et al., 2014; Spence et al., 2015). For Studies 2a and 2b, factors that may influence individual acceptance of smart technologies were explored using the context of climate change and energy reduction challenges and the potential of smart grids and smart energy technologies to tackle those challenges.

As discussed in Chapter 3, smart grids are of particular importance within smart city strategies as leaders aim to increase the environmental sustainability of cites. The importance of smart grids within smart city strategies translates into smart grids being important in the consideration of smart citizens (Giffinger et al., 2007; Karnouskos & De Holanda, 2009; Morvaj, Lugaric, & Krajcar, 2011; Washburn & Sindhu, 2010). The smart grid technologies have the potential to affect how consumers of electricity interact with the electricity generation and supply network (Gungor et al., 2013; R. H. Khan & Khan, 2013). For instance, the installation and use of smart energy technologies, such as the smart meters and home energy management systems (HEMS), will provide consumers with a means of interacting with, and responding to information from the electricity grid (Gungor et al., 2013;

R. H. Khan & Khan, 2013; Sintov & Schultz, 2015). These interactions between users and smart grids may be influenced by consumer acceptance of both the technology and requisite behaviours (such as, Paetz et al., 2012). Therefore, the smart grid technologies provided a context in which the influence of psychological empowerment, environmental concern, and environmental citizenship on citizen acceptance of smart technologies could be explored.

5.1.1 Exploring Acceptance of Smart Energy Technologies

Two studies were conducted to explore householder acceptance of using a Home Energy Management System (HEMS). The first study (Study 2a) was to explore acceptance of using the HEMS for energy reduction. The second study (Study 2b) was to explore using the HEMS for load shifting. The extended technology acceptance model (TAM2; Venkatesh & Davis, 2000) was used as an initial model. Then, to retain the broader considerations of the householders as smart citizens, the variables identified from the smart city literature (Chapter 2) and the interviews of Study 1, namely Psychological Empowerment, Environmental Citizenship, and Environmental Concern (identified in Chapter 4), were proposed as antecedents of the TAM2 factors *Perceived Usefulness* and *Intention to Use*.

The same technology, factors, research questions, and hypotheses were used in Studies 2a and 2b. Therefore, the following sections present the HEMS, the Technology Acceptance Model 2, Psychological Empowerment, Environmental Concern, and Environmental Citizenship, followed by the research questions and hypotheses. The method and results for each study are then be presented in turn, followed by an overall, combined discussion of the findings and implications of both studies.

5.1.1.1 The Home Energy Management System

HEMS are electronic devices, typically consisting of a display screen designed to provide the householder with information about their energy consumption (Bouhafs, Mackay, & Merabti, 2014). HEMS are tools to enable Demand Side Management (DSM), and provide the point at which householders will interface with the smart grid system. Essentially, they act as intermediary devices that can visualise, monitor and/or manage domestic gas and/or electricity consumption within the consumers' household (Van Dam, Bakker, & Van Hal, 2012). In conjunction with smart meters, HEMS can act as the ICT gateway for consumers to access the tailored information and services provided by the Advanced Metering Infrastructure (AMI) of the smart grid systems (such as real-time pricing or critical peaks information) and are therefore necessary for DSM programs (Giordano & Fulli, 2012; Kranz, 2011). HEMS are essential for creating accessible information for consumers, which is fundamental to enabling householders to become active participants in the smart grid system (El-Hawary, 2014; A. A. Khan, Razzaq, Khan, & Khursheed, 2015; Saad al-sumaiti, Ahmed, & Salama, 2014). However, householder acceptance of smart energy technologies and load shifting has been mixed when explored through focus groups (see Chapter 3).

5.1.1.2 The Technology Acceptance Model

The technology acceptance model (TAM) was developed by F. D. Davis (1989) to predict users' acceptance of technology from the users' internal beliefs about the usefulness and ease of use of the technology (see Figure 2). The TAM is a robust and parsimonious model for predicting technology acceptance (Yousafzai, Foxall, & Pallister, 2007) and has been applied to many different technologies, including communication systems, general purpose systems, office systems, and specialized systems (W. R. King & He, 2006; Y. Lee, Kozar, & Larsen, 2003). The focus on the usage of the technology as opposed to attitude towards it because F. D. Davis (1989) recognised that in some situations an individual may possess a positive attitude towards a technology, but not hold a positive attitude towards using it. It is the use of the smart energy technologies that will be critical to their acceptance as the potential user will have to (or at least be prompted to) engage with the technology to foster behaviour change. The perceived usefulness and perceived ease of use factors are explained below.

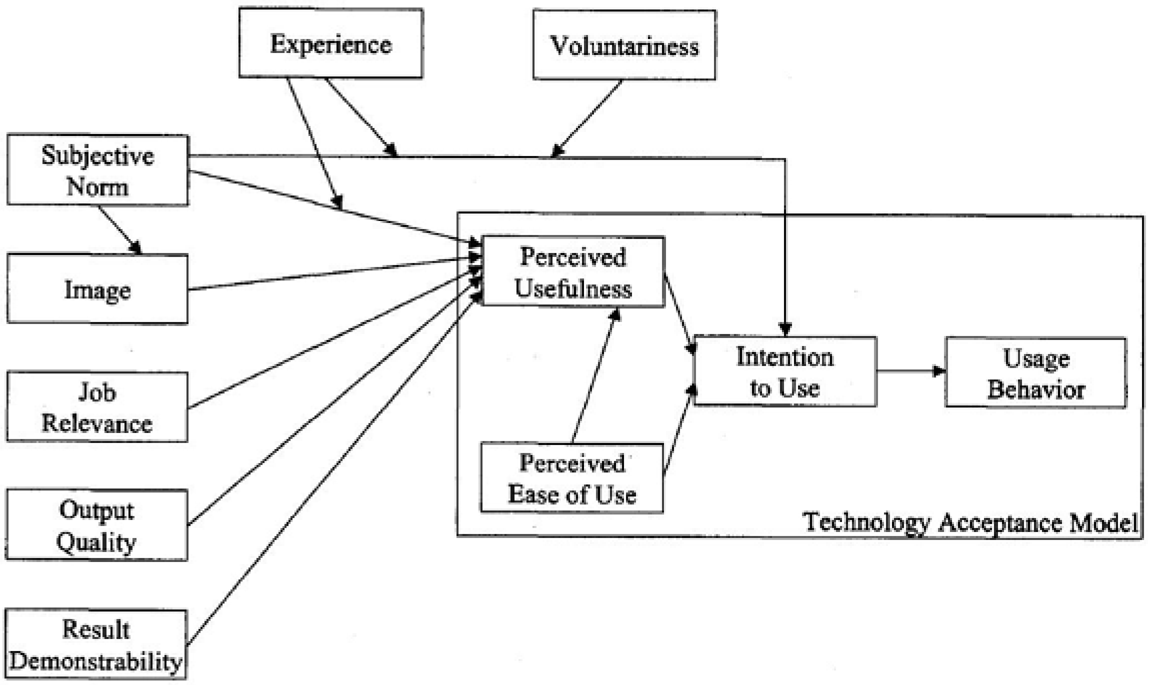


Figure 2. The Technology Acceptance Model 2 (TAM2; Venkatesh & Davis, 2000)

5.1.1.2.1 Perceived Usefulness and Perceived Ease of Use

The internal beliefs of *Perceived Usefulness* and *Perceived Ease of Use* (definitions in Table 8) have been found to be robust and reliable predictors of *Intention to Use* a technology, and actual usage of the technology (W. R. King & He, 2006; Shumaila, Gordon, & John, 2007). However, the basic TAM model does not provide any information about how these internal beliefs regarding the technology's usefulness or ease of use are formed by external variables (e.g. system characteristics, training). Therefore, there have been a large number of studies investigating the external predictors of the *Perceived Usefulness* and *Perceived Ease of Use* in different contexts (W. R. King & He, 2006). For example, in a review of the TAM, Shumaila et al. (2007) identify over 70 different external variables which they group under organizational, system, users' personal characteristics, and other variables.

To my knowledge, only two studies have investigated the acceptance of smart energy technologies using the TAM. Park, Kim, and Kim (2012) explored perceived electricity saving, perceived eco-environmental benefits (the extent to which the smart grid technologies are perceived to help the environment) and perceived risk of hacking. They found that to increase the perceived usefulness of smart grid technologies, it is necessary to enhance not only the technology's perceived ease of use, but also the perceived electricity saving potential, its eco-environmental friendliness, and the level of cyber-security safety. Relatedly, Park et al. (2012) found that the *Perceived Usefulness* of smart meters predicted individuals' intention to use them. Therefore, the *Perceived Usefulness* of the HEMS was identified as a potentially important factor in acceptance of the HEMS.

Perceived Ease of Use is the second internal belief regarding the technology. Whilst not explicitly measured as *Perceived Ease of Use*, an important aspect of smart energy technologies is whether the user perceives the technology to be easy to use (Solaimani, Keijzer-Broers, & Bouwman, 2013; Van Dam et al., 2012). This is because an inability to understand the output of smart energy technologies has been found to be a barrier to people using them (Broms et al., 2010; Costanza, Ramchurn, & Jennings, 2012; Goulden et al., 2014). If participants cannot understand the information or use them fully, they do not perceive them as useful (Hargreaves et al., 2013; Wilson et al., 2015) — as would be predicted from the TAM (F. D. Davis, 1989; W. R. King & He, 2006). As such, the *Perceived Ease of Use* of the HEMS was also identified as an important factor in the acceptance of the HEMS.

5.1.1.2.2 Cognitive Instrumental and Social Influence Processes

With the TAM2, Venkatesh and Davis (2000) extended the TAM by adding external variables to explain *Perceived Usefulness* (as shown in Figure 2). The full list of variables and their descriptions are shown in Table 8**.** These variables were proposed to be either cognitive instrumental processes (an individual's cognitive comparison between what the system is capable of doing and what the individual needs in order to attain their goal) or social influence processes (the social forces influencing an individual as they form a decision to accept or reject a technology). These provided a comprehensive set of factors with which to measure participants' perceptions of the HEMS. Therefore, the TAM2 was deemed a suitable model to explore the acceptance of the HEMS. It also offered a model to which the exploratory factors of *Psychological Empowerment*, *Environmental Citizenship,* and *Environmental Concern* could be added.

Table 8. Descriptions of the factors used in the TAM2.

	Factor	Description of TAM2 factor	Relating to the HEMS
	Perceived Usefulness	"The extent to which a person believes that using the system will enhance his or her job performance." [1]	The extent to which using the HEMS is perceived as enhancing their household energy management.
Cognitive Instrumental	Perceived Ease of Use	"The extent to which a person believes that using the system will be free of effort." [1]	The extent to which they believe using the HEMS will be free of effort.
	Result Demonstrability	The "tangibility of the results of using the innovation." [5]	The extent to which the results of using the HEMS are anticipated to occur.
	Output Quality	"Consideration [of] how well the system performs [its] tasks." [1]	The extent to which the HEMS is anticipated to perform its task.
	Job Relevance	"An individual's perception regarding the degree to which the target system is applicable to his or her job… job relevance is a function of the importance within one's job of the set of tasks the system is capable of supporting." [1]	Their perception of the degree to which the HEMS is applicable to their home. It will be a function of the importance of energy management within their home.
Social Influence	Voluntariness	"The extent to which potential adopters perceive the adoption decision to be non-mandatory." [2]	The extent to which they perceive the use of the HEMS to be non-mandatory.
	Image	"The degree to which use of an innovation is perceived to enhance one's . . . status in one's social system." [3]	The degree to which use of the HEMS is perceived to enhance the user's social status.
	Subjective Norm	"A person's perception that most people who are important to him think he should or should not perform the behaviour in question." [4]	Their perception of whether people who are important to him/her think he/she should or should not use the HEMS.

[1] Venkatesh and Davis (2000); [2] Agarwal and Prasad (1997); [3] Moore and Benbasat 1991, p. 195); [4] Fishbein and Ajzen (1975, p. 302); [5] Moore and Benbasat (1991)

5.1.1.3 The Exploratory, Smart Citizen Factors

5.1.1.3.1 Psychological Empowerment

In order to operationalise the abstract concept of empowered citizens identified in the literature review and Study 1 (e.g. Angelidou, 2014; Chourabi et al., 2012; Komninos, 2011; Lombardi et al., 2012; Naphade et al., 2011; Streitz, 2011), empowerment was considered in terms of psychological empowerment. Psychological empowerment is a cognitive state characterised by *Goal Internalisation, Perceived Competence,* and *Perceived Control* (Menon, 2001; Menon & Hartmann, 2002).

Goal Internalisation is a factor which goes beyond the personally meaningful aspect of a task (Arciniega & Menon, 2013). The "meaning" factor considered in other models of psychological empowerment relates to a specific task (Cattaneo & Chapman, 2010; Spreitzer, 1996; Thomas & Velthouse, 1990; Zimmerman, 1995). However, Menon (2001) developed the factor of goal internalisation to capture the motivating and inspiring effect of organisation level goals and aspirations. Therefore, *Goal Internalisation* is related to the extent to which the individual internalises the broader, organisational objectives, as opposed to their employee-level task related goals (Arciniega & Menon, 2013). The *Goal Internalisation* factor was used during Studies 2a and 2b (and 3) to refer to national level objectives for energy reduction (as an analogue of organisational objectives) in order to understand how a citizen's internalisation of a national goal would influence their acceptance of the HEMS.

Katz and Kahn (1978) suggest goal internalisation occurs when an individual incorporates the group or organisational goals into their own value systems. The internalised goals can then act as an intrinsic motivator and the individual will subsequently "choose to engage in tasks that have the greatest potential of achieving the group's or organisation's goal" Leonard, Beauvais, and Scholl (1999, p. 991). If an individual shares the governmental goal of UK energy reduction, then they may internalise it (Katz & Kahn, 1978). Therefore, as individuals internalise UK energy reduction targets, the goal of energy reduction may become of value to the individual, and act as a motivator for related behaviours (Bennis, 1995; Leonard et al., 1999). As such, they may perceive the HEMS (a technology that will help them achieve the internalised goal) as more useful and have a greater intention to use it.

The *Perceived Competence* factor of psychological empowerment relates to the concept of self-efficacy, i.e. the extent to which one believes they have the capabilities (including physical, cognitive and motivational) to accomplish a goal (Bandura, 1989). Within this study, the goal of using the HEMS was to manage one's energy consumption to either reduce consumption (Study 2a) or load shift the time of consumption (Study 2b), both of which have pro-environmental outcomes. Self-efficacy is an important predictor of pro-environmental behaviours, with greater perceived self-efficacy leading to greater engagement in pro-environmental behaviours (Bamberg & Möser, 2007; Kollmuss & Agyeman, 2002; Steinhorst, Klöckner, & Matthies, 2015). It could be argued that those who perceive themselves as competent enough to manage their energy use may feel that a HEMS is unnecessary and that they can successfully manage their energy consumption without it (suggesting a negative relationship between perceived competence and perceived usefulness). However, as noted in Chapter 3, there is evidence that users of smart energy technologies often use the technology as part of a 'next step' on their energy 'journey' to become more competent at managing energy consumption in their household (Hargreaves et al., 2010, p. 6114). Therefore, it was proposed in the present study that the more competent one perceives themselves being at managing their energy usage, the more useful they will perceive the HEMS as being for them.

Perceived Control over one's environment is a psychological state that is argued to be integral to psychological empowerment (Menon, 2001). This control can be considered to be the power to influence outcomes from different situations, such as in the community (Trickett, 1991) and is analogous to the perceived behavioural control construct in the theory of planned behaviour (Ajzen, 1991). Allen and Ferrand (1999) found that perceiving oneself as having personal control over improving the environment predicted greater intention to engage in pro-environmental behaviour. It was reasoned in the present study, that feeling able to influence others' energy consumption in the neighbourhood will lead individuals to feel more able to control over the goal (energy reduction/load shifting). Therefore, the more individuals perceive themselves as being able to have influence over energy reduction (Study 2a) and load shifting (Study 2b) in their neighbourhood the more useful they will perceive the technology as being

5.1.1.3.2 Environmental Concern

The interviewees of Study 1 discussed the need for citizens to transcend their self-interest and act for the benefit of the collective in order to achieve sustainability in the city. Stern et al. (1999) argues that the self-transcendent value of altruism predicts pro-environmental beliefs, as measured by the New Ecological Paradigm (NEP). The NEP has frequently been explored in relation to pro-environmental behaviours (Poortinga et al., 2004; Steg & Vlek, 2009). The NEP is considered to be a measure of individuals' agreement with principles relating to an ecological world-view (Dunlap, Liere, Mertig, & Jones, 2000) including; 1) humans are but one species among the many who are interdependent in the global eco-system 2) human activity is limited by the physical and biological constraints of a finite planet, and 3) human ingenuity cannot overcome all the biophysical constraints and ecological laws. Agreement with the NEP has been found to be related to such pro-environmental behaviours as participation in a premium-priced, green electricity programme (C. F. Clark, Kotchen, & Moore, 2003), paying for carbon off-setting (Choi & Ritchie, 2014), and greater reductions in energy consumption in response to rewards (Mizobuchi & Takeuchi, 2013). As the technologies are for energy management (either reduction or load shifting), their usage could be considered a pro-environmental behaviour. Therefore, it was proposed that greater environmental concern would predict greater perceived usefulness and intention to use the HEMS.

5.1.1.3.3 Environmental Citizenship

Environmental citizenship is regarded as: "the capacity of people around the world to inhabit a shared imagined community where global issues … are, first of all, visible in their interconnectedness, and secondly, in part as a consequence of this experience of sharedness, amenable to common regulation" (Luque, 2005). As such, Stern (2000) views environmental citizenship entailing being active in support environmental protection efforts and environmental activism. As past environmental behaviours, such as those an environmental citizen may engage in, predict future environmental behaviours (Knussen, Yule, MacKenzie, & Wells, 2004), it was argued that those who have been more active in their support of pro-environmental actions may be more motivated to adopt a technology that facilitates environmentally beneficial behaviours (i.e. the HEMS).

5.1.2 Research Questions for Study 2

To date, the TAM and TAM2 have predominantly been tested on acceptance of technology within the workplace (W. R. King & He, 2006; Schepers & Wetzels, 2007; Shumaila et al., 2007), therefore, the focus has been on the usefulness of the technology for achieving a work-related task. The HEMS, however, is for facilitating changes to energy use patterns, which may be beneficial to the environment and the wider goals of the city. Therefore, Study 2 aimed to explore the influence of the TAM2 factors and the exploratory, smart citizen factors on participants' intentions to use the HEMS. As such, the following research questions (RQ) were investigated:

- **RQ1**: Does the TAM2 provide a good model of acceptance of HEMS?
- **RQ2**: Is the TAM2's ability to predict HEMS acceptance augmented by the addition of goal internalisation, perceived control, perceived competence, environmental citizenship, and environmental concern?

5.1.3 Hypotheses for Studies 2a and 2b

To address RQ1 and in accordance with the TAM2 (and on the basis of the literature outlined above) it was predicted that:

- **Hypothesis 1:** The *Perceived Usefulness* of the HEMS would positively predict *Intention to Use* the HEMS.

- **Hypothesis 2:** *Perceived Ease of Use* of the HEMS would positively predict the *Perceived Usefulness* of the HEMS
- **Hypothesis 3**: Greater perceived *Voluntariness* would have a direct negative effect on *Intention to Use* the HEMS
- **Hypothesis 4**: *Subjective Norm, Result Demonstrability, Output Quality, Image, and Home Relevance* would have positive, mediated, effects on *Intention to Use* the HEMS through *Perceived Usefulness*

To address RQ2 and in accordance with the psychological empowerment, environmental concern, and environment citizenship literature outlined above it was predicted that:

- **Hypothesis 5:** Goal Internalisation, Perceived Competence, and Perceived Control would have positive, mediated, effects on *Intention to Use* the HEMS through *Perceived Usefulness*
- **Hypothesis 6**: Greater Environmental Concern will lead to greater Intention to Use the HEMS through the mediator of Perceived Usefulness.
- **Hypothesis 7**: Greater Environmental Citizenship will lead to greater Intention to Use the HEMS through the mediator of Perceived Usefulness.

The same hypotheses were explored in both Study 2a and Study 2b. Study 2a, which focused on acceptance of using the HEMS for energy reduction, will now be reported.

5.2 STUDY 2A: The HEMS and Energy Reduction

5.3 INTRODUCTION

The HEMS is a device which can provide the householder with greater information about their energy consumption (Beaudin & Zareipour, 2015). It is intended, as with other energy display devices, such as in home displays (IHDs), that the householder will be prompted to consume less energy once they are aware of areas in which they are wasting energy (Paetz et al., 2012; Van Dam et al., 2012). Study 2a explored acceptance of the HEMS as a device for energy reduction by framing the device as being for energy reduction only (i.e. there was no mention of load shifting).

5.4 METHOD

Study 2a received ethical approval from the University of Sheffield's Department of Psychology Ethics Committee.

5.4.1 The Approach: An Informed Questionnaire

Given that HEMS are still being developed, it was unlikely that participants would have had direct experience of using a HEMS. It was also possible that they would not be familiar with the environmental challenges leading to the need for new energy management strategies. Therefore, in an approach which drew on the Information and Choice

Questionnaire (ICQ) method (de Best-Waldhober et al., 2009) was used for Studies 2a and 2b (and Study 3). A key focus of the ICQ method is stimulating information processing and helping respondents reach a more informed decision (ter Mors et al., 2013). This help is provided by requesting respondents to give a quantitative evaluation of each of the presented consequences. Therefore, participants of Studies 2a and 2b were first provided with information to explain the need for energy reduction (Study 2a) and load shifting (Study 2b) and the role of the HEMS in achieving these goals. They were then asked to respond to a series of questions regarding the attitudes and expectations towards the HEMS.

Aspects of the ICQ were utilised in Studies 2a and 2b (and Study 3) because providing information about a problem and the asking participants to reflect on the possible solution has been shown to lead to participant opinions which are confident, stable over time, and consistent (Price & Neijens, 1997; Van Der Salm, Van Knippenberg, & Daamen, 1997). ICQs have also been shown to perform more favourably on these dimension relative to opinions generated through focus group discussion and presentation (ter Mors et al., 2013).

Providing information to describe and contextualise novel technologies or policies is a suitable method for eliciting informed responses from the participants on issues that are still be decided, such as smart grid technologies and the HEMS (Van Dam et al., 2012). Participants' responses may not necessarily be representative of the public's *current* support for the technology, but rather, what public support *could be* after they have been informed on the topic (de Best-Waldhober et al., 2009). Such research can therefore provide guidance on the way in which future technologies and their implications should be introduced to the public, through governmental policies or communications.

5.4.2 Research Design

The questionnaire was hosted by Qualtrics and participants completed the survey online. The flow of the questionnaire is shown in Figure 3. Participants were able to complete the questionnaire at their own pace, with an intended completion time of approximately 20 minutes.

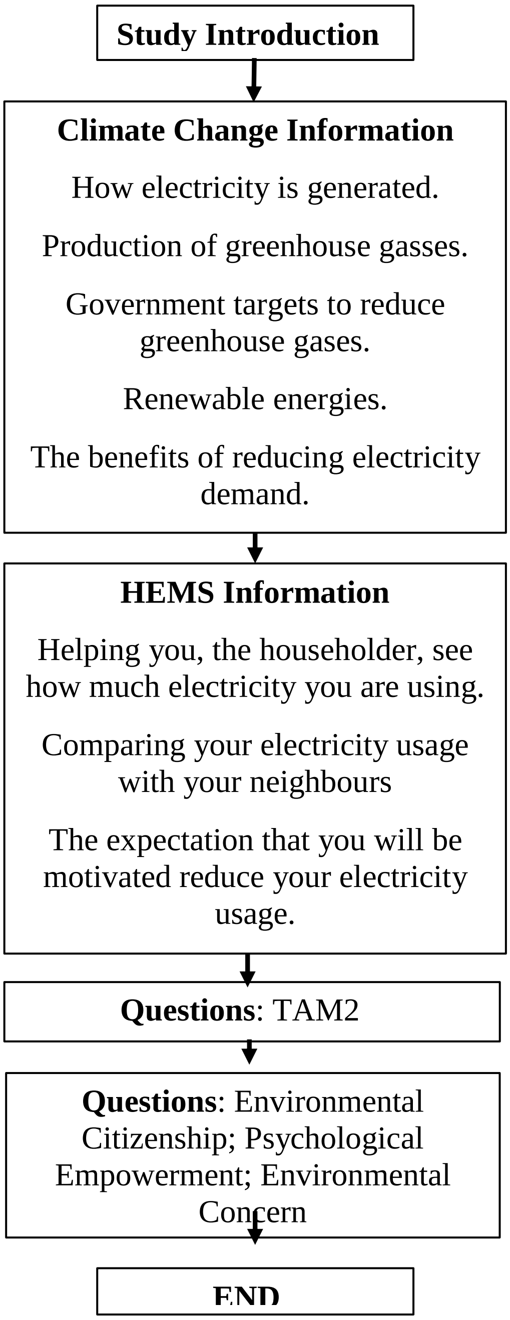


Figure 3. Diagram outlining the questionnaire flow for study 2a.

5.4.3 Materials

5.4.3.1 Generating the Information for the Informed Questionnaire

As per the ICQ methodology (de Best-Waldhober et al., 2009), the information given to the participants in the questionnaire presented a decision in the form of a problem and potential for solutions (the HEMS). The structure and key points of the information are shown in Figure 3 (the full information sheet is in Appendix C).

As study 2a focused on the energy reduction aspect of the HEMS, the information contained an explanation about greenhouse gases being produced as a result of burning fossil fuels for electricity generation in the UK. The problem was then defined as the environmental damage and impact on the earth’s climate that the greenhouse gasses have, and the UK government’s target to reduce their greenhouse gas emissions by 2030. The HEMS was then described in terms of being a technology to help with energy literacy and ultimately energy reduction by displaying your (the participant’s) energy consumption, as well as that of the neighbourhood, to encourage a reduction in electricity use. An explicit choice or preference is not always requested in the ICQ method, rather opinions on each the different options are collected (ter Mors et al., 2013). Therefore, opinions regarding the HEMS were collected (see the “Measures” section below).

The lead investigator generated the initial information on the HEMS and the problems associated with peak demands and greenhouse gasses. Content was based on academic publications on smart grids (e.g. Naus et al., 2014), load shifting (e.g. Gottwalt, Ketter, Block, Collins, & Weinhardt, 2011), neighbourhood energy feedback (e.g. Ilic, Da Silva, Karnouskos, & Griesemer, 2012) and home energy management systems (e.g. Beaudin & Zareipour, 2015; Khomami & Javidi, 2013; Van Dam, Bakker, & Buiter, 2013).

As smart technologies, such as the HEMS, are constantly under development and their capabilities and potentials can change, we wanted the energy technologies described in the information to reflect general trends as apparent in the smart energy technology literature. Therefore, higher-level descriptions of the key functionality and purpose of the technologies were favoured over lower-level technical descriptions of how they work.

5.4.3.2 Expert Consultation and Validation of Information

The participants' responses to the HEMS would be highly dependent on the information that was provided to them. It was therefore important that the information provided in the questionnaires was as unbiased, accurate and valid as possible (i.e. neither purposefully leading the participant nor misinforming them). Therefore, it was important that the generated information was evaluated and validated by experts (de Best-Waldhober et al., 2009).

In order to ensure the neutrality, accuracy, and validity of the explanations of the electricity generation problems and the technologies used in the information of the questionnaires, individuals with expertise in smart-grid technologies were contacted and consulted between April and June of 2014. Twenty-three experts were identified through an internet search for research groups and private companies who were involved in researching or developing smart grid related technologies. The identified groups or individuals were then contacted through email. The nature of the study was shared with them and they were invited to offer commentary and feedback on the information via an online survey (hosted by

Qualtrics), or email or telephone correspondence. Overall, twelve of the contacted experts responded.

The 12 experts who responded included: Eight smart grid technology researchers from academic institutions, a Senior Development Manager from a centre for sustainable energy, the Network Developer for a ‘green incubator’, the Head of Sustainable Communities at a regional energy centre, and a Director of Sustainability at an academic institution. Ten experts provided their feedback via Qualtrics, one gave face-to-face feedback and one gave feedback over the phone (responses were transcribed directly by the researcher).

The information underwent three drafts in an iterative process wherein alterations to the information based upon feedback from the first group of experts were made before being sent to a second group of experts. Eight of the 12 experts were in the initial group (those who responded first to the consultation request) and four in the second group (those who responded later to the consultation request). This was done to ensure that the researcher had implemented the first round of expert feedback successfully. At each stage, alterations were made to form and content, such as correcting a partially inaccurate explanation of load balancing, and including the intermittency of renewables as a motivator for smart grid development into the information.

At each stage the experts were allowed to respond with their feedback in their own time (up to a maximum of 4 weeks). All the experts were asked to what extent they found the information to be credible-dubious, trustworthy-untrustworthy, accurate-inaccurate, unbiased-biased, and clear-unclear on five point, bipolar scales. They could then provide qualitative explanations for their responses if they wished, as well as provide any further commentary on the information. All views expressed by individuals were their own and not representative of the groups or companies they work for. Full feedback from experts is available in Appendix F.

In order to ensure the readability and comprehensibility of the information for the intended participants, care was taken to avoid unnecessary technological and/or field-specific terminology and sentence length was kept short. The Flesch-reading ease test provided in the Microsoft Word was used to ascertain the reading age of the information. A Flesch score of 57.7 was attained. These scores are considered appropriate for a 13-15 year old reading level.

5.4.4 Measures

Due to the future-orientated, hypothetical nature of the technologies to which people were being asked to respond, there was a need to alter the items of the TAM2 and Intention to Use scales in order to reflect the fact that the respondents will not yet have had interaction with the technology. As such, when necessary the TAM2 and Intention to Use items were rephrased in terms of the participants' anticipated reactions. Items were also altered to reflect the HEMS. Examples questions for each of the factors are shown in Table 9. For a full list of the questions used in Study 2a, see Appendix C).

Table 9. Examples of Modified TAM2 Questions

Factor	TAM2 Question	Modified Question
Intention to Use	Assuming I have access to the system, I intend to use it	Assuming I have access to the HEMS, I intend to use it.
Perceived Usefulness	Using the system enhances my effectiveness in my job.	Using the HEMS would enhance my effectiveness on managing my energy usage.
Perceived Ease of Use	I find the system to be easy to use.	I would find the HEMS easy to use.
Subjective Norm	People who influence my behavior think that I should use the system.	People who influence my behaviour would think that I should use HEMS.
Voluntariness	My use of the system is voluntary.	I feel my use of HEMS would be voluntary.
Image	People in my organization who use the system have more prestige than	People in my neighbourhood who use HEMS have a high profile.
Job (Home) Relevance	In my job, usage of the system is important.	In my home, usage of the HEMS would be important.
Outcome Quality	The quality of the output I get from the system is high.	The quality of the output I would get from HEMS sounds like it will be high.
Result Demonstrability	I have no difficulty telling others about the results of using the system.	I would have no difficulty telling others about the results of using HEMS.

5.4.4.1 Intention to use and Attitudes towards Use of the Technologies

Intention to use the technology (i.e. the HEMS) was the main dependent variable of the analyses. Participants' intention to use each technology was measured using self-reported anticipated usage adapted from Fishbein and Ajzen (1975). There were two items: *"Assuming I have access to the HEMS, I intend to use it"* and "*If I had access to the HEMS, I predict* *that I would use it".* Responses were given on a 7-point Likert-scale anchored by Strongly Disagree (=1) and Strongly Agree (=7). The items' internal consistency was excellent (α=.94) and so the two items' scores were averaged to give a measure of *Intention to Use*.

Attitudes towards the use of the HEMS were measured using the attitude scale developed by Ajzen and Fishbein (1980). The attitude scale is a 5-item, 7-point bipolar adjective scale scored from 1 to 7. The adjectives are: good-bad, wise-foolish, favourable - unfavourable, beneficial-harmful, and positive- negative. Higher scores represent more negative attitudes. However, item scores were recoded for analysis so that higher scores indicated more positive attitudes. The items' internal consistency was excellent (α=.96) and so items were averaged to give an overall *Attitude towards Use* of the technology.

5.4.4.2 Technology Acceptance

Questions for the TAM2 were adapted from those used by Venkatesh and Davis (2000). The TAM2 scales have a varying number of items for each factor (shown in brackets) and measure participants' perceptions of a technology in terms of its *Perceived Usefulness* (6), *Perceived Ease of Use* (6), *Voluntariness* (3), *Image* (3), *Job Relevance* (2), *Output Quality* (2), *Result Demonstrability* (3), *and Subjective Norm* (2). Responses to each item were given on 7-point Likert-scales anchored by Strongly Disagree (=1) and Strongly Agree (=7). Cronbach alphas for the TAM2 scales were between .64 and .97. *Output Quality* (α =.64), *Voluntariness* (α=.68), and *Result Demonstrability* (α =.69) had alphas below the .70 cut-off discussed by (> .7; Mallery, 1999) as being an indication of good inter-item reliability. However, Kline (2013) suggests that below .70 is a realistic occurrence when measuring psychological constructs, as in the present study, and so items were averaged.

Given that the TAM2 questions were originally designed for measuring responses to technologies in the workplace, for the present study the items were also adapted to be context specific for this study (i.e. that they are technologies for the home that are intended for energy management). For example, for the TAM2 scale *Perceived Usefulness*, the item's wording was altered from *"Using the system in my job increases my productivity"* to *"Using the HEMS in my home would increase my ability to control my energy use".* See Table 9 for further examples.

Whilst "Actual Usage" and "Experience" are two factors in the TAM2, these could not be measured as it was anticipated that participants would not have used the HEMS previously (although this was not checked, see the Discussion).

5.4.4.3 Psychological Empowerment scale

Menon's (1999) measure of psychological empowerment was selected for use in this study. It has three subscales; goal internalisation, perceived control, and perceived competence. Menon's (1999) psychological empowerment scale has only been used in occupational settings (Arciniega & Menon, 2013; Menon, 2001; Menon & Hartmann, 2002) and so the items were adapted to relate to the energy goals of the UK, rather than of an organisation. UK energy reduction goals were chosen in order to have the participant consider the objectives of the UK to reduce energy consumption. For example, the goal internalisation item, *"I am inspired by what we are trying to achieve as an organization"* was modified to be "*I am inspired by the energy reduction we are trying to achieve in the UK"*. Perceived competency items were also altered to reflect energy use (*"I have the skills and abilities to do my job well"* became *"I have the skill and abilities to reduce my energy use"*) as were the perceived control items (*"I can influence the way work is done in my department"* became *"I can influence energy decisions in my neighbourhood"*). The perceived control factor was focused at the neighbourhood level (as opposed to the individual household level) as this more closely reflects the level of the original scale i.e. it is a householder's perceived control over their neighbourhood, rather an employee's over their department. All item responses were on a 6-point Likert scale (1= Strongly disagree *to* 6=strongly agree). The items' internal consistency was excellent (HEMS α=.96) and so the averages of each of the items were used to form the score for *Goal Internalisation, Perceived Control, and Perceived Competence*.

5.4.4.4 Environmental Citizenship scale

Environmental citizenship was measured using a scale developed by Stern (2000). It was used by Stern to assess levels of general, non-activist support for the environmental movement (Stern, 2000; Stern et al., 1999). The scale consists of 7 questions regarding whether the participant has engaged in a non-activist environmental behaviour or not over last 12 months (such as signing a petition in support of protecting the environment). Responses are recorded dichotomously as either "no" or "yes". A "no" response was numerically coded as 1 and "yes" was coded as 2. Scores were then summed with a minimum of 7 and a maximum of 14 possible. A score of 14 would indicate the high levels of environmental citizenship.

5.4.4.5 General Environmental Concern scale

Participants' general environmental concern was assessed using the revised New Ecological Paradigm (NEP) measure (Dunlap et al., 2000). The NEP is intended to measure the participants' views regarding the vulnerability of the natural environment to human interference (Poortinga, Steg, & Vlek, 2002). It is frequently used with environmental psychology as a proxy for individuals' general concern for the environment and is used in the present study as such (Hawcroft & Milfont, 2010; Poortinga et al., 2004). Items consist of statements relating to the human-nature relationship. Agreement with the eight odd–numbered items (*such as "Humans are severely abusing the environment"*) and disagreement with the seven even–numbered items (such as *"The earth has plenty of natural resources if we just learn how to develop them"*) indicate pro–NEP responses i.e. high environmental concern. All item responses were on a 5 point Likert scale (1= strongly disagree *to* 5=strongly agree). For analysis, the seven negatively worded statements were recoded such that greater scores indicated higher environmental concern. Cronbach's alpha (α=.80) was satisfactory and so item scores were averaged to generate as an indicator of concern for the environment with higher scores indicating greater concern (Poortinga et al., 2004).

5.4.5 Piloting the Informed Questionnaire

In order to test the readability and comprehensibility of the information, the questionnaire was piloted on a small opportunity sample of participants (5 males, 7 females. Age range 18-58). Participants completed either a paper-based or online version of the questionnaire. Written and verbal feedback was invited from the participants regarding any issues with the information or questions. Feedback indicated that the participants had understood the information and were able to answer the question items. Some small grammatical alterations were made to the information for greater clarity as a result of the feedback.

5.4.6 Participants for Main Study

5.4.6.1 Participant Recruitment

Previous studies have found that student responses to the TAM are not representative of non-student populations (W. R. King & He, 2006) and so, in order to maximise the generalizability of the findings, a diverse sample population was sought. Accordingly, the study was advertised to university staff members and users of Twitter and Facebook. University staff members were invited to take part via email. Staff email lists at the University of Sheffield, Sheffield Hallam University, University of Manchester, and Aston Business School were used to deliver the invitations. These lists typically include both academic and non-academic staff members within the institution. The email was sent with the subject "Survey on Household Energy Use (Prize Draw: £100 first prize, £50 second prize)" and outlined the nature of the study and what participation would entail. Information about how participant data would be used and stored was given and the right to withdraw stated. The participants were informed that by starting the survey they were giving their consent. The invitation email is available in Appendix B.

A link to the questionnaire was also shared via the social media site Twitter and in a number of Facebook groups for buying and selling items. By following the advertised link, participants were taken to the survey and the same information and right to withdraw as in the staff emails was presented. For both the staff emails and social media sites, an incentive in the form of entry to a competition to win a high-street shopping voucher (either a £100, a £50 or one of three £10) was used. The survey was opened on 04/10/2014 and closed on the 20/02/2015.

In total, 187 participants started the questionnaire, with 115 participants completing and submitting the questionnaire (i.e. completion rate = 59.2%).

5.4.6.1.1 Influential Outliers

In order to check for multivariate outliers within the dataset, a multiple regression was conducted for the HEMS using *Intention to Use* as the outcome and the TAM2 factors, psychological empowerment, environmental citizenship and environmental concern scores as predictors. The Mahalanobis distances were then used to identify potential outlying cases within the datasets (Field, 2009). On this basis, there were 3 outlying cases. However, inspection of the Cook's distance, showed that they each had a Cook's distance <1 which, suggests that they did not having a concerning level of influence on the model as a whole (R. D. Cook & Weisberg, 1982) and so it was not justifiable or necessary to delete them (Simonoff, 2013; Stevens, 2012).

5.4.6.1.2 Missing Data

Whilst the “request response” option was used in Qualtrics in order to remind participants to fill in items without responses before they moved on to the next section, there were still cases with missing data in the data set. Five cases were missing more than 50% of items, and so they were deemed unusable in the analysis, and so were removed from the data set. Of the remaining 110 cases, 7 cases had missing data, which totalled 18 missing data points.

Little’s MCAR test (Little, 1988) was used to distinguish between Missing at Random (MAR) and Missing Completely at Random (MCAR) data. The chi-square test was non-significant (χ^2 (433) = 416.10 p=.71). Indicating that the data was MCAR and does not reflect any systematic response bias. In order conserve as many of the cases as possible (and maintain sample size), multiple imputation was used to estimate and replace the missing values. The statistical analysis software SPSS version 21 was used to conduct the multiple imputation (Yuan, Qin, Wu, & Tang, 2012). All 18 missing data points were successfully imputed.

5.4.6.2 Demographics

After the data cleaning process, a total of five participants had been removed a final *n* of 110. The largest percentage of participants owned the property they were living in, lived in a terraced house, and had obtained a university degree (see Table 11). The age group with the highest frequency of response was 38-41 years, with the second highest being 54-57 years (see Figure 4).

As shown in Table 10, in terms of psychological empowerment, on average, participants shared the goal of UK energy management and perceived themselves as competent enough to manage their energy use. However, they did not perceive themselves as having control over their neighbourhoods' energy consumption. Furthermore, participants indicated an intention to change their energy behaviours. Finally, participants indicated they had engaged in citizenship behaviours and felt some general concern for the environment.

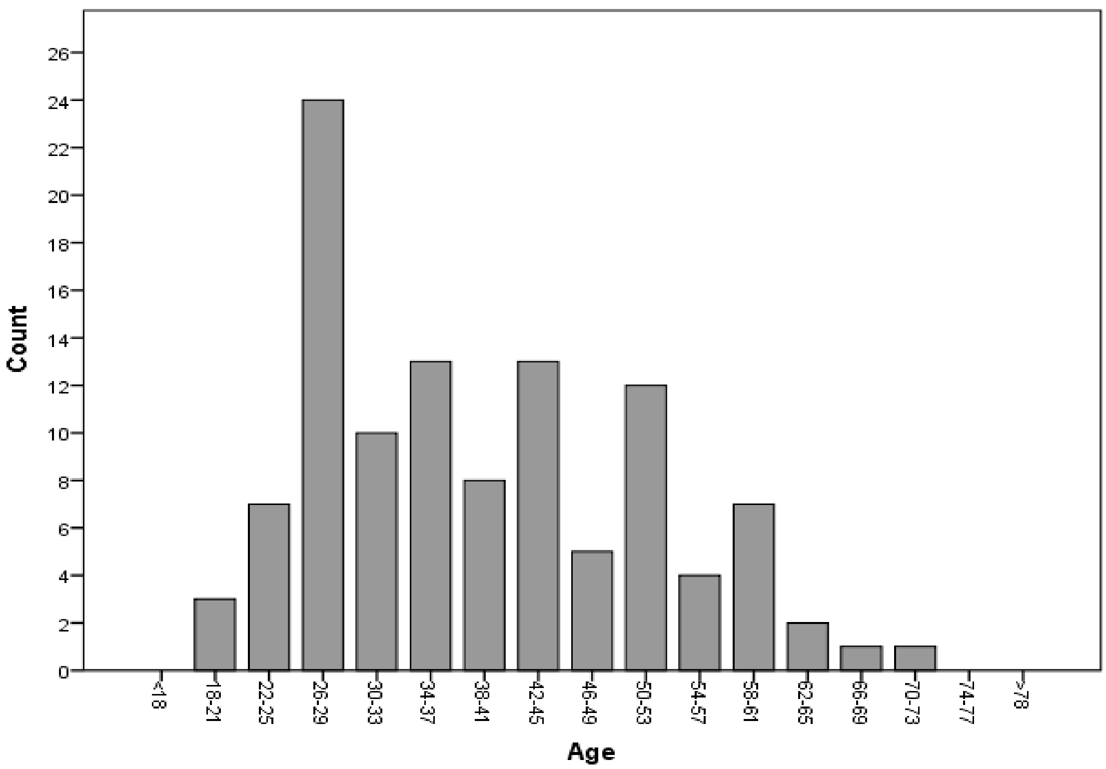


Figure 4. Response frequencies for categories of participants' age in Study 2a

Table 11. Frequencies of property ownership, property type, and educational attainment in Study 2a

	Frequency	Percentage		Frequency	Percentage
Property Ownership			**Educational Attainment**		
Renting the property	37	33.6	GCSE/O-level	6	5.5
Own the property	66	60.0	A/AS level	8	7.3
Other	7	6.4	University Degree	35	31.8
Property Type			Master's Degree	29	26.4
Detached	25	22.7	Doctorate Degree	27	24.5
Semi-Detached	33	30.0	Other	5	4.5
Terrace	34	30.9			
Flats	18	16.4			

N= 110

Table 10. Mean participant scores for psychological empowerment, intention to change energy behaviour, environmental citizenship, and environmental concern.

Subscale	Mean (*SD*) *n*=110
Goal Internalisation	4.36 (1.01)
Perceived Control	2.13 (1.12)
Perceived Competency	4.87 (0.79)
Intention to change energy behaviour	4.23 (1.14)
Environmental Citizenship	9.85 (2.25)
Environmental Concern	3.91 (0.53)

Scales: Goal Internalisation, Perceived Control, and Perceived Competency (1-6); Environmental Citizenship (7-14); Environmental Concern (1-5)

5.5 Results for Energy Reduction Study 2a

5.5.1 Perceptions of the HEMS

One sample *t*-tests were initially used to assess whether the participants' mean scores on the TAM2 variables significantly deviated from the midpoint of the scales as an indication of agreement (significantly above the midpoint), disagreement (significantly below the midpoint) or uncertainty (not significantly different from the midpoint). The means and statistics are shown in Table 12.

On average, participants' indicated a significant *Intention to Use* the HEMS ($p < .001$) and were significantly positive regarding the technologies' *Perceived Usefulness*, *Home Relevance* and they held a positive *Attitude* towards using the technology ($p < .001$).

In terms of understanding the technologies, participants perceived themselves as capable of using the HEMS and able to explain its purposes to someone (*Result Demonstrability* variable; $p < .001$). Additionally, the participants indicated they felt the HEMS would perform its described task well (*Output Quality*; $p < .001$).

In terms of the social influence factors of the TAM2, participants, on average, indicated they did not agree that the use of the HEMS would provide an increase in social status (*Image* variable; $p < .001$). Furthermore, participants indicated that they were unsure about whether people who influence them would want them to use the HEMS (*Subjective Norm;* $p = .57$). Finally, participants perceived the HEMS as *Voluntary* ($p < .001$).

Table 12. Mean scores and significance tests for deviation from the midpoint for TAM2 responses to the HEMS in Study 2a

Subscale	HEMS Mean (SD)	*t*	*p*
Intention to Use	5.60 (1.44)	11.55	**.00**
Perceived Usefulness	5.45 (1.33)	11.36	**.00**
Perceived Ease of Use	5.33 (1.07)	12.94	**.00**
Voluntariness	5.25 (1.12)	11.66	**.00**
Image	2.55 (1.25)	-12.05	**.00**
Home Relevance	5.00 (1.35)	7.71	**.00**
Output Quality	5.15 (1.14)	10.54	**.00**
Result Demonstrability	5.38 (0.91)	15.86	**.00**
Subjective Norm	4.08 (1.40)	0.58	.57
Attitude	5.87 (1.16)	16.85	**.00**

Note: Significance values based on 10,000 bootstrapped sample. TAM2 Scale Midpoint = 4; Significant p values are emboldened. N = 110; df = 109

5.5.2 Predicting Intention to Use the HEMS in Study 2a

In order to address the RQs and hypotheses (as outlined in the section 5.2.1) two simple mediation models were tested on the data. The first model was the TAM2 (RQ1) and the second was the Augmented TAM2 (RQ2), which consisted of the significant predictors of the TAM2, as well as the exploratory factors of *Psychological Empowerment, Environmental Citizenship* and *Environmental Concern*.

To test the simple mediation models, a regression based approach using the SPSS macro PROCESS was used (Hayes, 2013). This estimates the effects of 1) the predictors on the mediator, 2) the mediator on the dependent variable (DV), and 3) the direct effect of the predictors on the DV. It then estimates the effect of the mediator. Statistical significance of the mediation is determined by estimating the confidence intervals (Cortina & Dunlap, 1997; Hayes, 2013). If zero (0) is not contained within the range of the lower and upper confidence intervals, then it gives confidence that the true (population) estimate value will be greater than zero and therefore there is an influence (an effect). As bootstrapping was used for all analyses, the confidence intervals are generated from the resampling and replacing method and so they are bias corrected confidence intervals.

For both the TAM2 and Augmented TAM2, *Intention to Use* the HEMS was the DV, with the hypothesised factors entered as predictors of *Intention to Use* and *Perceived Usefulness* entered as the mediator.

In the first model (for RQ1), the TAM2 predictors were entered (Hypotheses 1 to 4). The full TAM2 results are not presented here for the purposes of space. The full results can be found in Appendix G. However, the linear model for predicting *Perceived Usefulness* was significant $R^2 = .69$, $F(7, 102) = 32.79$, $p < .001$. Only *Home Relevance* and *Perceived Ease of Use* were significant predictors. Equally, the linear model for predicting *Intention to Use* the HEMS was significant $R^2 = .71$, $F(8, 101) = 31.39$, $p < .001$ and *Home Relevance* and *Perceived Usefulness* were significant predictors.

The significant predictors from the TAM2 model were entered in to the second model (i.e. the Augmented TAM2) along with the *Goal Internalisation, Perceived Competence, Perceived Control, Environmental Concern,* and *Environmental Citizenship* as predictors (Hypotheses 5 to 7). The full analysis of the Augmented TAM2 is presented below.

5.5.3 Results for Predicting Intention to Use the HEMS with the Augmented TAM2

5.5.3.1 Assumption checking for Predicting Intention to Use the HEMS

Correlation matrices (available in Appendix D) were inspected for correlations between predictors that were >.8 or >.9 as this is an indicator of possible multicollinearity (Field, 2009). There were no correlations of concern for the HEMS.

Inspection of the scatterplots of the standardised residuals against the standardised predicted values for both regressions of the predictors on *Intention to Use* indicated there may be an issue of heteroscedasticity in the HEMS regression model. P-P plots of each of the predictors showed all predictors had a linear relationship with the outcome. The scatterplot of the standardised residuals indicated no issues with linearity for the overall model. Inspection of the p-p plots for the standardised residuals and the histogram indicated that the residuals of the regression model had a normal distribution.

In order to account for the heteroscedasticity, bootstrapping was used to estimate the standard errors and confidence intervals as bootstrapped regressions are robust against assumption violations (J. Fox, 2015; Preacher, Rucker, & Hayes, 2007; Russell & Dean, 2000; Williams, Grajales, & Kurkiewicz, 2013). Bootstrapping was used for all regression models in Study 2a.

5.5.3.2 Linear Models for Perceived Usefulness and Intention to Use

As shown in Table 14, the linear model for predicting *Perceived Usefulness* of the HEMS from the independent variables (IV) was significant $R^2 = .69$, $F(7, 102) = 32.97$, $p < .001$, suggesting a large proportion of the variance (69%) in participants' perceptions of the HEMS' usefulness was able to be explained by the augmented TAM2 predictors. Likewise, the linear model for *Intention to Use* the HEMS was also significant $R^2 = .72$, $F(8, 101) = 33.15$, $p < .001$, suggesting that a large proportion (72%) of the variance within participants' Intentions to Use the HEMS can be explained by the Augmented TAM2 predictors.

5.5.3.3 Predictors of Perceived Usefulness and Intention to Use

Perceived Usefulness of the HEMS was predicted by *Perceived Ease of Use* ($\beta = .26$) and *Home Relevance* ($\beta = .67$). Inspection of the bias corrected bootstrapped confidence intervals (Table 13) showed that both *Perceived Ease of Use* (.02 to .37) and *Home Relevance* (.15 to .54) had an indirect effect on *Intention to Use* the HEMS via *Perceived Usefulness* ($\beta = .54$). *Home Relevance* maintained an independent positive influence on the *Intention to Use* the HEMS ($\beta = .23$).

Environmental Citizenship had a direct influence on *Intention to Use* the HEMS ($\beta = .11$), which suggested that the more support the participants indicated they had for pro-environmental causes, the more they intended to use the HEMS. The Psychological Empowerment variables and Environmental Concern were not significant predictors of *Perceived Usefulness* or *Intention to Use*. The model was re-estimated with only the significant predictors and is shown in Figure 5.

Table 14. Model coefficients for the Augmented TAM2 (Study 2a)

Antecedent (X)		Consequent: Perceived Usefulness (M) Std. Coeff.(β)	SE	p		Intention to Use the HEMS (Y) Std. Coeff. (β)	SE	p
	a							
Perceived Ease of Use		.27	.06	**.00**		.11	.07	.09
Home Relevance		.69	.06	**.00**		.25	.09	**.01**
Goal Internalisation		.01	.06	.91		.09	.06	.13
Perceived Control		-.01	.06	.90		.01	.05	.84
Perceived Competency		.03	.06	.51		.00	.06	.95
Environmental Concern		-.07	.06	.25		-.10	.06	.10
Environmental Citizenship		-.03	.06	.60		.11	.06	**.05**
Perceived Usefulness (Mediator)		-	-	-	*b*	.53	.09	**.00**
Constant	i_i	.00	.06	1.00		.00	.05	1.00
		$R^2 = .69$				$R^2 = .72$		
		$F(7, 102) = 32.97$ $p < .001$				$F(8, 101) = 33.15$ $p < .001$		

Standard Error (SE) estimated from a bias-corrected bootstrap sample of 10,000. Variables that are significant (α = .05) are emboldened. N=110.

Table 13. Estimates of the indirect effects of predictors on Intention to Use HEMS as mediated by Perceived Usefulness in Study 2a

Antecedent	Std. Coeff. (β)	SE	Lower level CI	Upper level CI
Perceived Ease of Use	.15	.09	.02	.37
Home Relevance	.37	.10	.17	.55
Goal Internalisation	.00	.04	-.07	.09
Perceived Control	.00	.02	-.05	.05
Perceived Competency	.02	.04	-.05	.10
Environmental Concern	-.04	.04	-.14	.01
Environmental Citizenship	-.02	.03	-.07	.04

Confidence intervals (CI) and Standard Error (SE) estimated from a bias-corrected bootstrap sample of 10,000. Lower and Upper CIs without 0 in their range are emboldened.

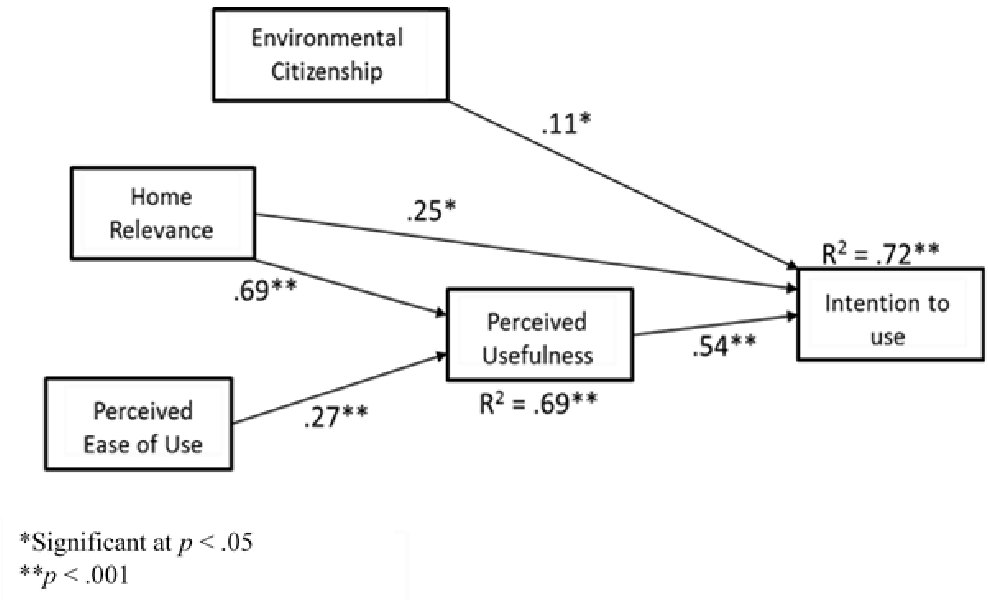


Figure 5. Final model for predicting Intention to Use the HEMS in Study 2a

5.5.4 Further exploration of Home Relevance - Testing for Moderation (2a)

Moderators are an underexplored area of the TAM, with many researchers focusing on the antecedents of *Perceived Usefulness* and/or *Intention to Use* the technology as opposed to the influence an interaction variable could have on the predictors' relationships (W. R. King & He, 2006). Given the unexpected direct relationship of *Home Relevance* on *Intention to Use* it was deemed important to develop the understanding of the relationship further, through a moderation analysis.

The psychological empowerment construct of *Goal Internalisation* was hypothesised as a negative moderator of the effect of *Home Relevance* on *Intention to Use.* Internalised goals can become a source of motivation for the individual to engage in collective or shared goals (Leonard et al., 1999; Quinn & Burbach, 2008). On the other hand, the *Home Relevance* construct is related to the individual's goals in their home (Venkatesh and Davis, 2000). Therefore, there may be a conflict between the internalised, collective goals, and the more individualistic home goals. For instance, Leonard et al. (1999) suggest that when conflict arises between different behaviours, the individuals who have internalised collective goals will commit themselves to the action that will most likely achieve the shared, group goal(s).

It was proposed in the present study that the sharing of the values of the UK energy targets might undermine more individualistic goals of home energy management when individuals are considering their intentions towards using an energy management technology. Consequently, it was additionally hypothesised that: *Goal Internalisation* will negatively moderate the effect of *Home Relevance* on *Intention to Use* the HEMS.

The interaction term was added to the mediation model using PROCESS. Moderation levels were determined by the pick-a-point approach, which uses one standard deviation (*SD*) below the mean (-1), the mean, and one standard deviation above the mean (+1) to give the respective equivalent of relatively low, moderate, and relatively high levels of the moderating variable (Aiken, West, & Reno, 1991). Once again, bootstrapping was used to calculate confidence intervals as is recommended for models with interaction terms (Preacher et al., 2007; Russell & Dean, 2000).

As shown in Table 16, Goal Internalisation and Home Relevance had a significant negative interaction ($\beta = -.12$, $p = .02$). The moderation analysis (shown in Table 15) indicates that at higher levels of Goal Internalisation (+1 SD), Home Relevance no longer significantly influenced Intention to Use ($p = .12$). This decrease in the effect of Home Relevance suggests that participants' perceptions of the relevance of the HEMS to their home had less influence on their Intention to Use the HEMS if they experienced higher internalisation of UK energy goals. *Environmental Citizenship* was no longer a significant predictor and so the moderated model was re-estimated without it. The final, full moderation model is shown in Figure 6.

Table 16. Model coefficients for Goal Internalisation moderating the effect of Home Relevance on Intention to Use the HEMS (Study 2a).

		Consequent						
		Perceived Usefulness (M)				Intention to Use the HEMS (Y)		
Antecedent (X)		Std. Coeff. (β)	SE	p		Std. Coeff. (β)	SE	p
Perceived Ease of Use	*a*	.27	.06	**.00**	*c'*	.09	.06	.14
Environmental Citizenship		-.05	.05	.35		.08	.05	.12
Home Relevance		.69	.06	**.00**		.26	.09	**.00**
Goal Internalisation		-	-	-		.09	.06	.14
Goal Internalisation × Home Relevance		-	-	-		-.12	.05	**.02**
Perceived Usefulness (Mediator)		-	-	-	*b*	.53	.09	**.00**
Constant	i_1	.00	.05	1.00	i_2	.04	.05	.43
		$R^2 = .69$				$R^2 = .73$		
		$F(3, 106) = 78.27$ $p < .001$				$F(6, 103) = .46.68$ $p < .001$		

Standard Error (SE) estimated from a bias-corrected bootstrap sample of 10,000.
Variables that are significant (α = .05) are emboldened.

Table 15. The conditional direct effect of Home Relevance on Intention to Use at values of Goal Internalisation (Study 2a)

Goal internalisation (*SD*)	Std. Coeff.(β)	SE	*P*	Lower level CI	Upper level CI
-1.00	.38	.10	.00	.18	.59
.00	.26	.09	.00	.10	.43
1.00	.14	.10	.14	-.05	.33

Confidence intervals (CI) and Standard Error (SE) estimated from a bias-corrected bootstrap sample of 10,000. N.B. As the variables have been standardised, their mean values are 0.

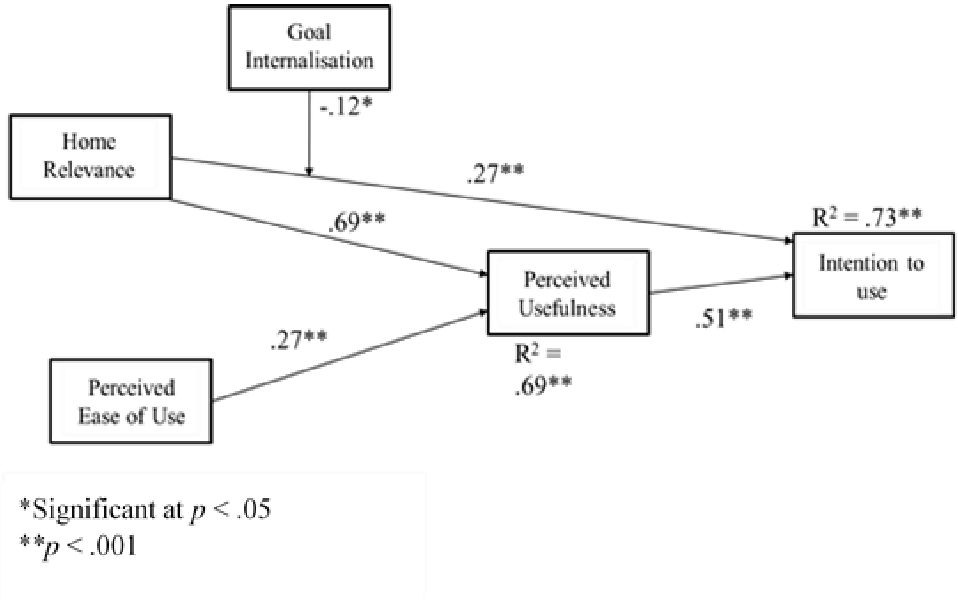


Figure 6. Conceptual model for predicting Intention to Use the HEMS with Goal Internalisation moderator (Study 2a).

5.5.4.1 Summary of Predicting Intention to Use the HEMS in Study 2a

Supporting the original TAM, *Perceived Usefulness* mediated the effect of *Perceived Ease of Use* on the *Intention to Use* the HEMS (supporting hypotheses 1 and 2). All effects were positive, which suggested that as participants perceived themselves as being more capable of using the HEMS, this increased their perceptions of the HEMS as being useful. In turn, perceiving the HEMS as useful increased their intention to use it. Additionally (and in line with the TAM2), *Perceived Usefulness* mediated the effect of perceived *Home Relevance* on the *Intention to Use* the HEMS (partially supporting hypothesis 4). The other TAM2 factors were not statistically significant predictors (hypothesis 3 was not supported and hypothesis 4 was partially not supported).

Home Relevance was found to also directly predict the *Intention to Use* the HEMS. Such a direct effect was not found in the TAM2, and was not hypothesised in the present study. Once again, all effects were positive, suggesting that greater perceptions of the HEMS being relevant to the participant's home lead increased their *Intention to Use* it, both directly and indirectly through *Perceived Usefulness*.

Following a moderated mediation analysis, it was found that *Goal Internalisation* negatively moderated the direct effect of *Home Relevance* on *Intention to Use* the HEMS. This suggested that the greater the participants scored on *Goal Internalisation*, the less their perceptions of the HEMS' *Home Relevance* directly influenced their *Intention to Use* the HEMS. Indeed, when *Goal Internalisation* scores were one standard deviation (*SD*) above the mean, the direct effect of *Home Relevance* was statistically non-significant.

None of the Psychological Empowerment factors, or *Environmental Citizenship* or *Environmental Concern* variables significantly predicted either the *Perceived Usefulness* or *Intention to Use* the HEMS in the moderated mediation model. Therefore, the addition of the Psychological Empowerment variables, *Environmental Citizenship*, and *Environmental Concern* did not contribute to the TAM2 for predicting intention to use the HEMS (hypotheses 5 to 7, therefore, were not supported).

5.6 STUDY 2B: HEMS and Load Shifting

5.7 INTRODUCTION

Study 2a explored the perceptions of the HEMS when it was described as a device for facilitating and encouraging a reduction in electricity consumption. Study 2b, on the other hand, explored perceptions of the HEMS when it was described in terms of its other energy management potential, that is to facilitate and encourage individuals to shift the time of their electricity consumption in order reduce peaks in electricity demand (Cheah, Zhang, Gooi, Yu, & Foo, 2012). This load shifting is part of the Demand Side Management (DSM) strategies, which are facilitated by smart grid developments (Goulden et al., 2014) and seen as the way to increase load flexibility into the grid and reduce the need for inefficient peak power stations (see Chapter 3). Study 2b, therefore, aimed to explore acceptance of the HEMS when it was framed as being a load shifting device. Study 2b followed the same method and used the same scales as Study 2a, therefore, less detail is provided for Study 2b

5.8 METHOD

Study 2b received ethical approval from the University of Sheffield's Department of Psychology Ethics Committee.

5.8.1 Materials

5.8.1.1 Generating and Expert Validation of the Information for Participants

The structure and key points of the information used in the questionnaire are shown in Table 17 (the full information is in Appendix E). The information contained an explanation of peak demands in the UK, and the current methods of electricity consumption estimation. The problem was then defined as being the need to reduce peaks in electricity demand by changing when they (the participant) use their electricity, and also the need for network operators to be able to monitor electricity consumption more accurately in order to then be able to generate electricity more efficiently. Real time pricing was then explained. The technological option (presented as a solution to peak demand) was the HEMS. The HEMS was described to the participant in terms of being a technology to help with awareness of energy consumption, and ultimately energy reduction, by displaying their energy consumption, as well as that of the neighbourhood, to encourage a reduction in electricity use (the full questionnaire is in Appendix E). A Flesch score for readability of 52.3 was attained. These scores are considered appropriate for a 13-15 year old reading level.

The load shifting information for Study 2b was written and validated at the same time and by the same process and experts as the climate change information of Study 2a.

Table 17. Key points of the questionnaire information presented to participants (Study 2b).

Load Shifting
• Current prediction method of electricity generation. • Peak consumption and generation times. • Difficulty of matching supply and demand. • Network operators’ need for more information about electricity usage
HEMS
• Providing system operators with real time electricity usage information. • How real time pricing will operate. • How using electricity at off-peak times will save you money. • The expectation for you to shift usage behaviour to avoid peaks.

5.8.2 Measures

The same measures were used in the present study as were used in Study 2a. These included the TAM2 scales of Perceived Usefulness, Perceived Ease of Use, Voluntariness, Image, Job Relevance, Output Quality, Result Demonstrability, and Subjective Norm; The Intention to Use and Attitude towards Use scales; the Environmental Concern scale (NEP), and Environmental Citizenship scales; and the psychological empowerment scales of Goal Internalisation, Perceived Competence, and Perceived Control. All scale items had internal reliability of $\alpha > .07$ (Kline, 2013) and were averaged or summed in the same manner as in Study 2a.

5.8.3 Participant Recruitment and Research Design

Participants were recruited through the same methods as outlined in Study 2a and at the same time. The survey was hosted by Qualtrics.com and participants completed the survey online. The flow of the questionnaire is was the same as for Study 2a. Participants were able to complete the questionnaire at their own pace, with an intended completion time of approximately 20 minutes.

5.8.4 Participants

In total, 189 participants started the questionnaire, with 108 participants completing and submitting the questionnaire (i.e. response rate = 57.67%). Demographic information is provided below.

5.8.4.1 Influential Outliers

The same procedures as described in study 2a was used to identify multivariate outliers. Inspection of the Mahalanobis distances and Cook’s distances indicated no influential outliers in the models.

5.8.4.2 Missing Data

One case was missing more than 50% of items were therefore deemed unusable in the analysis and so were removed from the data. The remaining 107 cases had 7 cases with missing data (6.54%), which totalled 11 missing data points.

Little's MCAR test (Little, 1988) was used to distinguish between Missing at Random (MAR) and Missing Completely at Random (MCAR) data. The chi-square test was non-significant (χ^2 (892) = 840.46, p = .89). As the Little's MCAR test was non-significant it is possible to say that the data is MCAR and did not reflect any systematic response bias. However, in order conserve as many of the cases as possible (and maintain sample size), multiple imputation was used to estimate and replace the missing values. The statistical analysis software SPSS version 21 was used to conduct the multiple imputation (Yuan et al., 2012). All 11 missing data were successfully imputed.

5.8.4.3 Demographics

As noted above, one participant was removed from the leaving a final *n* of 107. The largest percentage of participants owned the property they were living in, lived in a semi-detached house, and had obtained a doctorate degree (see Table 19). The age group with the highest frequency of response was 38-41 years; with the second highest being, 54-57 years (see Figure 7).

As shown in Table 18, in terms of psychological empowerment, on average, participants shared the goal of UK energy management and perceived themselves as competent enough to manage their energy use. However, they did not perceive themselves as having control over their neighbourhoods' energy consumption. Participants indicated an intention to change their energy behaviours. Finally, participants indicated they had engaged in environmental citizenship behaviours, and felt some general concern for the environment.

Table 18. Mean scores for psychological empowerment, intention to change energy behaviour, environmental citizenship, and environmental concern (Study 2b).

Subscale	**Mean (*SD*) *n*=110**
Goal Internalisation[1]	4.17 (1.04)
Perceived Control[1]	2.29 (1.22)
Perceived Competency[1]	5.04 (0.75)
Environmental Citizenship[3]	9.61 (2.19)
Environmental Concern [2]	3.75 (0.63)
Intention to change energy behaviour[4]	4.27 (1.85)

Scale ranges: 1-6[1]; 1-5[2]; 7-14[3]; 1-7[4]

Table 19. Frequencies for property ownership, property type and educational attainment (Study 2b)

	Frequency	%		Frequency	%
Property Ownership			**Educational Attainment**		
Renting the property	38	36.4	GCSE/O-level	7	6.5
Own the property	66	61.7	A/AS level	7	6.5
Other	2	1.9	University Degree	30	28.0
Property Type			Master's Degree	21	19.6
Detached	20	18.7	Doctorate Degree	40	37.4
Semi-Detached	40	37.4	Other	2	1.9
Terrace	29	27.1			
Flats	18	16.8			

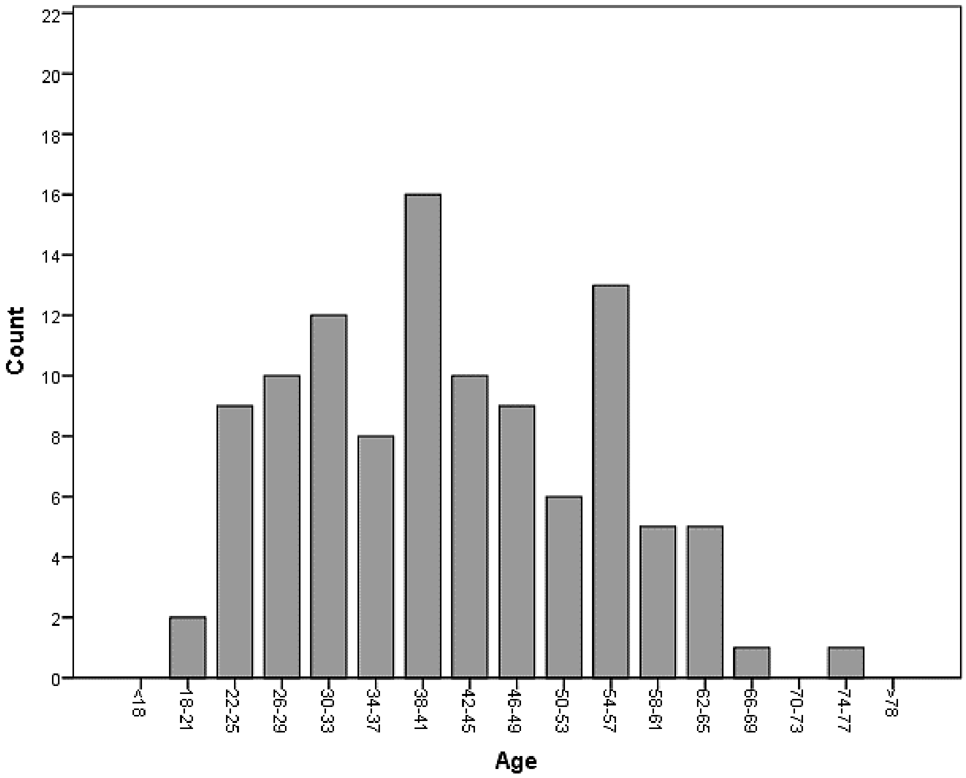


Figure 7. Response frequencies for categories of age (Study 2b)

5.9 Results for Study 2b

5.9.1 Perceptions of the HEMS

One sample *t*-tests were initially used to assess whether the participants' mean scores on the TAM2 variables significantly deviated from the midpoint of the scales as an indication of agreement (significantly above the midpoint), disagreement (significantly below the midpoint) or uncertainty (not significantly different from the midpoint). The means and statistics are shown in Table 20.

In terms of the cognitive instrumental factors of the TAM2, on average, participants' indicated that they perceived the HEMS to be useful, and relevant to their home (*Perceived Usefulness* and *Home Relevance* factors respectively; $p < .001$). Furthermore, participants perceived themselves as capable of using the HEMS, that it would give them high quality of output, and that they would be able to explain the HEMS' purposes to someone (*Perceived Ease of Use, Output Quality,* and *Result Demonstrability* factors, respectively; $p < .001$). Finally, participants had, on average, a positive attitude towards using the HEMS and indicated an intention to use it (*Attitude towards Use* and *Intention to Use* factors, respectively; $p < .001$).

Perceptions were more mixed in terms of the social influence factors of the TAM2 regarding use of the HEMS. Whilst, on average, participants felt that usage of the HEMS would be voluntary (*Voluntariness* $p < .001$), participants also indicated they did not agree that the use of the HEMS would give status to a user within their neighbourhood (*Image* factor; $p < .001$). Furthermore, participants indicated that they were unsure about whether people who are important to them would want them to use the HEMS ($p = 1.00$).

Table 20. Mean scores and significance tests for deviation from the midpoint for TAM2 responses to the HEMS (Study 2b)

Subscale	HEMS Mean (*SD*)	*t*	*p*	*Indicates*
Intention to Use	5.51 (1.58)	9.90	**.00**	Agree
Perceived Usefulness	5.27 (1.46)	8.95	**.00**	Agree
Perceived Ease of Use	5.08 (1.16)	9.65	**.00**	Agree
Voluntariness	4.67 (1.22)	5.65	**.00**	Agree
Image	2.74 (1.31)	-9.98	**.00**	Disagree
Home Relevance	4.75 (1.69)	4.61	**.00**	Agree
Output Quality	4.87 (1.43)	6.32	**.00**	Agree
Result Demonstrability	5.27 (1.10)	11.87	**.00**	Agree
Subjective Norm	4.00 (1.39)	0.00	1.0	Unsure
Attitude	5.64 (1.43)	11.83	**.00**	Positive

Note: Significance values based on 10,000 bootstrapped sample. Scale Midpoint of TAM2 =4; Significant p values are emboldened. N = 107; df = 106

5.9.2 Predicting the Intention to Use the HEMS in Study 2b

As with Study 2a, two simple mediation models were tested using the SPSS add on, PROCESS. Consistent with TAM2, *Intention to Use* the HEMS was the DV, with the hypothesised predictors entered as predictors of *Intention to Use*, and *Perceived Usefulness* was entered as the mediator.

In the first model (for RQ1), the TAM2 predictors were entered (Hypotheses 1 to 4). The full TAM2 results are not presented here and the full results can be found in Appendix I. However, the linear model for predicting *Perceived Usefulness* was $R^2 = .71$, $F(7, 99) = 34.76$, $p < .001$, however, only *Home Relevance, Perceived Ease of Use,* and *Image* were significant predictors. Equally, the linear model for predicting *Intention to Use* the HEMS was $R^2 = .83$, $F(8, 98) = 61.19$, $p < .001$, but only *Home Relevance* and *Perceived Usefulness* were significant predictors.

The significant predictors from the TAM2 model were entered in to the second model (i.e. the Augmented TAM2) along with the *Goal Internalisation, Perceived Competence, Perceived Control, Environmental Concern,* and *Environmental Citizenship* as predictors (Hypotheses 5 to 7). The full analysis of the Augmented TAM2 is presented below.

5.9.3 Results for Augmented TAM2 in Study 2b

5.9.3.1 Assumption testing for Augmented TAM2 predictors

The same procedure as study 2a was used to test assumptions for the models used in the present study. Inspection of the Mahalanobis distances and Cook's distances indicated no influential outliers in the model. The HEMS model showed no issues of multicollinearity or non-linearity. The HEMS model showed slight heteroscedasticity. The p-p plots of the standardised residuals and the histogram indicated that the residuals of the regression model had a normal distribution. In order to account for the heteroscedasticity, bootstrapping was used to estimate the standard errors and confidence intervals as bootstrapped regressions are robust against assumption violations (J. Fox, 2015; Preacher et al., 2007; Russell & Dean, 2000; Williams et al., 2013). Bootstrapping was subsequently used for all regression models in Study 2b.

5.9.3.2 Linear Models for Perceived Usefulness and Intention to Use

As can be seen in Table 21, the linear model for predicting *Perceived Usefulness* of the HEMS from the TAM2 variables was significant $R^2 = .77$, $F(8, 98) = 39.89$, $p < .001$, suggesting a large proportion of the variance (77%) in participants' perceptions of the HEMS' usefulness was able to be explained by the augmented TAM2 predictors. Likewise, the linear model for *Intention to Use* the HEMS was also significant $R^2 = .84$, $F(9, 97) = 55.97$, $p < .001$, suggesting that a large proportion (84%) of the variance within participants' Intentions to Use the HEMS were explained by the TAM2 predictors.

5.9.3.3 Predictors of Perceived Usefulness and Intention to Use

As can be seen in Table 21, *Perceived Usefulness* directly predicts participants' *Intention to Use* the HEMS ($\beta = .64$). It can also be seen that greater perceptions of the HEMS' *Perceived Ease of Use* ($a = .25$) and *Home Relevance* ($\beta = .47$) predicts higher levels of *Perceived Usefulness*. In addition, greater *Goal Internalisation* ($\beta = .25$) and *Environmental Concern* (as measured by the NEP, $\beta = .11$) also predict greater *Perceived Usefulness* of the HEMS. By being above zero, the bias corrected confidence intervals (Table 22) indicates there is an indirect effect of *Goal Internalisation* (.05 to .35), *Perceived Ease of Use* (.08 to .29), *Home Relevance* (.05 to .35) and *Environmental Concern* (.00 to 2.0) on *Intention to Use* the HEMS, through its *Perceived Usefulness*. The perception of *Home*

Relevance maintains an independent, direct positive influence on *Intention to Use* the HEMS (β = .29). The model was re-estimated without the non-significant predictors. The resulting estimates are shown in Figure 8.

Table 21. Model coefficients for Augmented TAM2 (Study 2b)

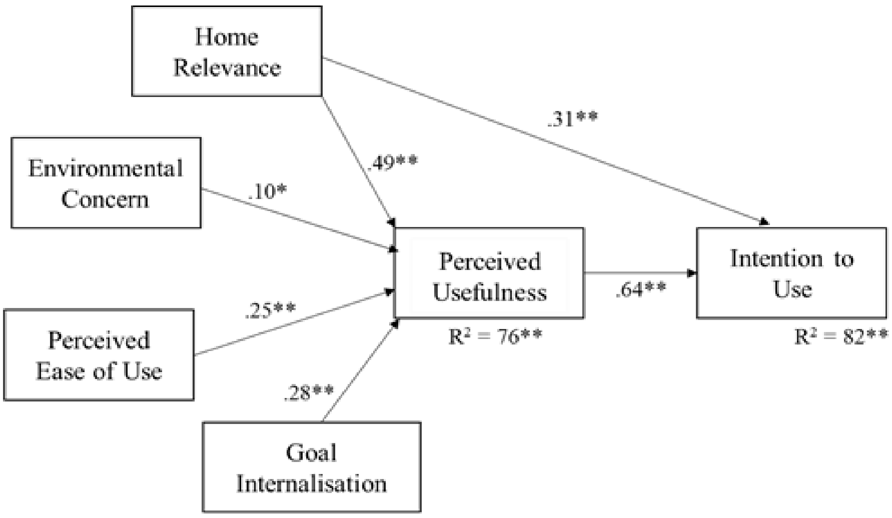
		Consequent						
		Perceived Usefulness (M)				Intention to Use the HEMS(Y)		
Antecedent (X)		Std. Coeff. (β)	SE	*p*		Std. Coeff. (β)	SE	*p*
Perceived Ease of Use	*a*	.25	.06	**.00**	*c'*	-.01	.05	.85
Image		.10	.07	.14		-.09	.06	.12
Home Relevance		.48	.07	**.00**		.30	.07	**.00**
Goal Internalisation		.25	.07	**.00**		.09	.06	.14
Perceived Control		-.06	.06	.31		-.07	.05	.17
Perceived Competency		.01	.06	.81		-.04	.05	.35
Environmental Concern		.11	.06	**.05**		.00	.05	.93
Environmental Citizenship		.04	.06	.46		.06	.04	.18
Perceived Usefulness (Mediator)		-	-	-	*b*	.64	.08	**.00**
Constant	i_i	.00	.05	1.00	i_2	.00	.04	1.00
		R^2 = .77				R^2 = .84		
		$F(8, 98)$= 39.89 p < .001				$F(9, 97)$= 55.97 p < .001		

Standard Error (SE) estimated from a bias-corrected bootstrap sample of 10,000. Variables

Table 22. Estimates of the indirect effects of predictors on Intention to Use HEMS as mediated by Perceived Usefulness (Study 2b).

Antecedent	Std. Coeff. (β)	SE	Lower level CI	Upper level CI
Perceived Ease of Use	.16	.05	**.07**	**.28**
Image	.06	.04	-.02	.14
Home Relevance	.30	.09	**.17**	**.50**
Goal Internalisation	.16	.08	**.04**	**.35**
Perceived Control	-.04	.04	-.12	.03
Perceived Competency	.01	.04	-.08	.08
Environmental Concern	.07	.05	-.00	.19
Environmental Citizenship	.03	.04	-.04	.10

Confidence intervals (CI) and Standard Error (SE) estimated from a bias-corrected bootstrap sample of 10,000. Lower and Upper CIs without 0 in their range are emboldened.



*Significant at $p < .05$
**$p < .001$

Figure 8. Conceptual Figure for significant augmented TAM2 variables for predicting Intention to Use the HEMS in the load-shifting condition (Study 2b).

5.9.4 Further exploration of Home Relevance - Testing for Moderation (2b)

As the same, direct effect of *Home Relevance* on *Intention to Use* as in Study 2a was found, the moderating effect of *Goal Internalisation* was tested. The test for the moderating effect of *Goal Internalisation* was conducted using the same methods as outlined in Study 2a.

Table 24 shows *Goal Internalisation* and *Home Relevance* have a significant negative interaction (β = -.12, p < 01). Table 23 shows the effect of *Home Relevance* on *Intention to Use* the HEMS at different levels of *Goal Internalisation*. The effect of *Home Relevance* on *Intention to Use* remains significant at each level. At the higher level of *Goal Internalisation* (+1 *SD*), however, the effect of *Home Relevance* on *Intention to Use* decreases (compared to the mean and -1 *SD*) and the confidence intervals approach zero. This suggests that the more participants internalise the UK energy goals, the less influential the relevance the HEMS has for their home has on their *Intention to Use* it. The conceptual model is shown Figure 9.

Table 24. Model coefficients for Goal Internalisation moderating the effect of Home Relevance on Intention to Use the HEMS (Study 2b).

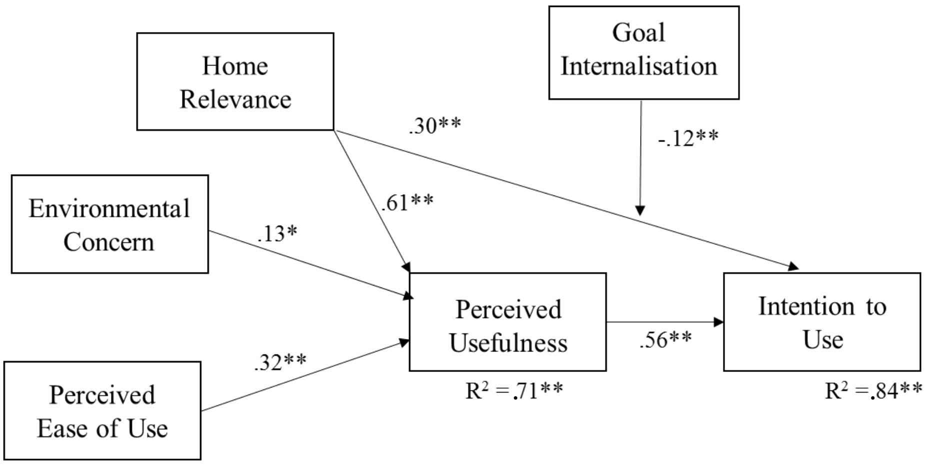
		Consequent						
		Perceived Usefulness (M)				Intention to Use the HEMS(Y)		
Antecedent (X)		Std. Coeff. (β)	SE	*p*		Std. Coeff. (β)	SE	*p*
Perceived Ease of Use	*a*	.32	.06	**.00**	*c'*	.01	.05	.91
Home Relevance		.61	.06	**.00**		.30	.06	**.00**
Environmental Concern		.13	.05	**.02**		.01	.04	.74
Goal Internalisation		-	-	-		.02	.06	.78
Goal Internalisation × Home Relevance		-	-	-		-.12	.04	**.00**
Perceived Usefulness (Mediator)		-	-	-	*b*	.56	.04	.00
Constant	i_1	.00	.05	1.00	i_2	.00	.05	1.00
		$R^2 = .71$				$R^2 = .84$		
		$F(3, 103) = 83.44$ $p < .001$				$F(6, 10) = 88.53$ $p < .001$		

Standard Error (SE) estimated from a bias-corrected bootstrap sample of 10,000.

Table 23. The conditional direct effect of Home Relevance on Intention to Use at values of Goal Internalisation (Study 2b).

Goal Internalisation (*SD*)	Std. Coeff. (β)	SE	*p*	Lower level CI	Upper level CI
-1.00	.41	.07	.00	.27	.55
.00	.30	.06	.00	.17	.42
1.00	.18	.08	.02	.03	.33

Confidence intervals (CI) and Standard Error (SE) estimated from a bias-corrected bootstrap sample of 10,000.



*Significant at p< .05
**p< .001

Figure 9. Conceptual model for predicting Intention to Use the HEMS in the Load Shifting condition with moderator (Study 2b).

5.9.4.1 Summary for Predicting Intention to Use the HEMS in Study 2b

As with Study 2a, and supporting the original Technology Acceptance Model (F. D. Davis, 1989), *Perceived Usefulness* mediated the effect of *Perceived Ease of Use* on the *Intention to Use* the HEMS (supporting hypothesis 2). Furthermore, *Perceived Usefulness* also mediated the effect of perceived *Home Relevance* on the *Intention to Use* the HEMS (supporting hypothesis 4), although *Home Relevance* still directly predicted the *Intention to Use* the HEMS (not hypothesised). Once again, all effects were positive.

As with Study 2a, the moderated mediation analysis showed that *Goal Internalisation* had a negative moderation effect on the direct influence of *Home Relevance* on *Intention to Use*. Unlike Study 2a, *Environmental Concern* was a significant predictor of *Intention to Use* the HEMS and was mediated by *Perceived Usefulness* (supporting hypothesis 6). This suggested that the greater the participant's concern for protecting the environment, the more they perceived the HEMS as being useful to them, which then increased their *Intention to Use* the HEMS.

5.10 DISCUSSION

It has been argued that householder acceptance of smart energy technologies (and the associated behaviour changes) will be important for the realisation of many of the future energy management strategies enabled by smart grid systems. The present study sought to explore the acceptance of the Home Energy Management Systems (HEMS) using the established Technology Acceptance Model 2 (TAM2), and the exploratory (Smart Citizen) variables of psychological empowerment, environmental concern, and environmental citizenship.

Study 2a focused on using the HEMS to reduce energy consumption in order to reduce greenhouse gas production and limiting environmental damage. It was found that perceiving the HEMS as being easy to use and relevant to their home, increased participants' perceptions that it was useful. Perceiving the HEMS as useful then increased their intention to use it. In addition, perceiving the HEMS as relevant to their home also directly increased participants' intention to use it. However, being inspired by the UK goals to reduce energy consumption reduced this influence.

Study 2b focused on using the HEMS to load shift household energy consumption and reduce peak demands in electricity. A similar model to Study 2a was found. In addition to the factors of the Study 2a model, however, being concerned for the environment also increased participants' perceptions that the HEMS was useful.

The overall, positive perception of and intention to use the HEMS contributes to the understanding of consumer responses to smart grid technologies. A growing number of studies are exploring consumer acceptance of HEMS and load shifting, with mixed positive and negative responses being found across focus groups and interviews (e.g. Goulden et al., 2014; Paetz et al., 2012) and few studies have explored acceptance of smart energy management technologies quantitatively (e.g. Mah et al., 2012). Developing a predictive model of intention to use the HEMS has highlighted factors that will be important for ensuring householders accept use of the HEMS and other smart energy technologies. The non-significant predictors in the models will be discussed first, followed by the significant ones. Wider implications of the findings will then be discussed, followed by limitations, and conclusions.

5.10.1 The non-significant predictors

The majority of the predictors hypothesised in Studies 2a and 2b did not significantly predict the perceived usefulness or intention to use the HEMS. However, previous studies using the TAM2 predictors have also found mixed levels of influence for the model's predictors (Chismar & Wiley-Patton, 2003; Rondan-Cataluña, Arenas-Gaitán, & Ramírez-Correa, 2015). In addition, the exploratory variables were not significant predictors either, except for environmental concern in Study 2b.

In the TAM2, Venkatesh and Davis (2000) argue that the extent to which people perceive others as gaining prestige for using the technology will influence the peoples' intention to use the technology themselves. This was not found, however, in Studies 2a or 2b as *Image* did not significantly predict *Intention to Use* the HEMS or their perceived usefulness. This is perhaps a surprising finding considering how in other technological domains, such as smart phones, gaming devices, televisions etc., image or gains in social status are discussed as important motivators for consumers to purchase the device (Salo, Kajalo, Mäntymäki, Sihvonen, & Leminen, 2013; Yu, Lee, Ha, & Zo, 2015). The lack of influence of Image may have been due to the fact that participants in both Studies 2a and 2b actually disagreed that using the HEMS would give people in their neighbourhood greater social status. This may be due to energy management currently being a mainly private practice. It follows that if participants did not feel the use of the HEMS would grant them any greater social status, they are unlikely to derive motivation to use the technology from *Image* considerations.

Subjective norms are an antecedent to intention in the Theory of Planned Behaviour (TPB) and have frequently been found to predict behaviour via intentions (Rivis & Sheeran, 2003). Schepers and Wetzels (2007) conducted a meta-analysis of the TAM and found a significant influence of subjective norms on perceived usefulness and intention to use. Therefore, the lack of predictive power of subjective norms in the present study is surprising. The fact that *Subjective Norms* did not predict intentions to use the HEMS might have been due to the unfamiliar nature of the technology. As the HEMS is a new technological concept, perceived subjective norms regarding its use are probably yet to be established. As HEMS become more commonplace it is likely that subjective norms will become more predictive of intentions to use i.e. when norms for use of the HEMS become established.

The lack of experience of the HEMS may also explain the non-significance of the *Result Demonstrability* and *Output Quality* factors. The assessment of how well the system performs its task, and the tangibility of the results would have been based on participants making inferences from the information provided to them in the questionnaire. Although this is true of all the perceptions of the HEMS in the two studies, the *Perceived Usefulness* and

Home Relevance factors are based partly on what the participants' current needs and wants from using a technology, such as the HEMS, are. *Result Demonstrability* and *Output Quality*, however, actually require the participant to have received something from the technology on which to make an assessment, i.e. does it match their expectations. Therefore, the result demonstrability and output quality predictors may be less suited for research into the acceptance of hypothetical (either unexperienced or not yet developed) technologies.

Participants did not perceive themselves as having control over their neighbourhood's energy usage and *Perceived Control* did not have a significant influence on perceptions of usefulness or intentions to use the HEMS. The emphasis in Studies 2a and 2b were on how the technology would affect "you" (i.e. the participant). As such, the HEMS was portrayed as being a private technology for use in the individual's home. Therefore, it was perhaps not important to individuals about whether they would able to influence their neighbourhood's energy consumption or not. Perhaps, if the more collective elements of the future of energy management were highlighted further (i.e. emphasise that energy reduction and load shifting are shared goals), then concerns related to influence within the neighbourhood would become more important.

Participants perceived themselves as competent enough to manage their energy consumption. However, *Perceived Competence* had no significant influence on perceptions of usefulness or intentions to use the HEMS. It could be that there was not enough distinction between the participants' *Perceived Ease of Use* of using the technology and their *Perceived Competence* in energy management. It is also probable that the perceived ease of use of the HEMS influenced participants' perceived competence (Menon, 2001). As participants perceived the HEMS as being easy for them to use, their perceived competence in energy management was of no consequence as the technology would either manage their energy for them (automatizing it) or make it easy for them to do themselves.

Finally, *Environmental Citizenship* was not able to predict perceived usefulness or intention to use the HEMS. This may be because the indication in both Study 2a and 2b was that the participants did not engage in many activities in support of the environment (i.e. they were not very active environmental citizens). The low levels of environmental citizens within the sample may have explained the absence of *Environmental Citizenship* as a predictor within the current study. It is possible that if a more environmentally active sample were recruited that this would have been retained as a predictor.

5.10.2 Predicting Intention to Use Smart Grid Technologies

Whilst *Perceived Usefulness* and *Perceived Ease of Use* (in Study 2a), and *Environmental Concern* (Study 2b) were the only predictors of perceived usefulness and intention to use, they accounted for a large percentage of the variance (60% to 71% in Study 2a and 68% to 74% in Study 2b). Whilst it was only the *Intention to Use* the HEMS that was measured and not actual usage, *Intention to Use* has been found to correlate with, and predict actual usage (Schepers & Wetzels, 2007; Turner et al., 2010). Therefore, the models offer a good explanation of participants' intention to use the HEMS and can be used to explore acceptance of smart energy technologies, particularly those intended for use in the home.

Studies 2a and 2b supported the considerable TAM literature, which shows perceiving a technology as useful increases the individual's intention to use it (W. R. King & He, 2006; Schepers & Wetzels, 2007; Shumaila et al., 2007). They also demonstrated, once again, that to understand the acceptance of technology further, it is important to understand the antecedents for *Perceived Usefulness* (Chin & Gopal, 1995; Venkatesh & Davis, 2000). In the case of the HEMS, therefore, Studies 2a and 2b suggested that householders will need to feel that using it will enhance his or her household energy management (perceived usefulness), a feeling which will be increased by perceiving the HEMS as being easy to use and relevant to their household.

The observed effect of *Home Relevance* on *Perceived Usefulness* and *Intention to Use* demonstrates that considering individuals' goals for energy consumption in their home will be important when designing and implementing smart energy technologies. For instance, in defining the TAM2 construct of Job Relevance, Venkatesh and Davis (2000) pointed to research on knowledge structures and suggest that individuals will have unique and specific knowledge regarding the respective importance of their different job goals. I argue that this will be equally true for the individual in their home environment. People have multiple considerations and have multiple goals when using energy in their home, such as cooking, cleansing, leisure, and heating (Selvefors, Karlsson, & Rahe, 2015). Therefore, goals for reducing energy consumption will not be regarded as important or prioritised if the energy reduction goals cannot be incorporated into the individuals' everyday life without threatening or conflicting with the individuals' primary goals, such as their basic needs, or desires (Selvefors et al., 2015).

The moderating effect of goal internalisation on home relevance suggests that the greater extent to which people are inspired by the broader UK energy goals, the less their intention to use the HEMS is influenced by the specific home relevance of the technology. Such an interaction between, what could be considered, the more psychological distant, abstract goals of the UK, and the closer, more concrete goals of the home, can be related to construal level theory (CLT). For instance, psychologically distant, abstract goals are driven by values and desires, whereas psychologically closer, concrete goals are driven by feasibility and convenience (Eyal, Sagristano, Trope, Liberman, & Chaiken, 2009; Trope & Liberman, 2010). Therefore, when individuals are inspired by UK energy goals, the decision to use the

HEMS is influenced by how it is perceived to facilitate advancement towards the valued UK energy goals. In contrast, when individuals are less inspired by UK energy goals, the decision to use the HEMS is more influenced by narrower, pragmatic considerations of how the technology will work in the home and what benefit it will be for them.

5.10.3 The differences between Studies 2a and 2b

The models that were developed in Study 2a and in Study 2b had the same final predictors in them. The main difference, however, was that in Study 2b (i.e. load shifting study) the *Environmental Concern* scores predicted the *Perceived Usefulness* of the HEMS, which was not the case in Study 2a. The findings of Study 2b support findings from other environmental behaviour studies, which have shown environmental concern is associated with greater support for government policy and market regulation for environmental protection, as well as greater support for household energy management strategies (Mizobuchi & Takeuchi, 2013; Poortinga et al., 2002, 2004). However, it was found that the *Environmental Concern* was not a predictor in Study 2a, despite Study 2a having a greater focus on energy reduction than Study 2b did. This would (tentatively) suggest that environmental concern may have more influence on the perceptions of smart energy technologies when the technology is presented in a load shifting context as opposed to energy reduction. This finding will be discussed further in Chapter 7 (the overall discussion). However, such comparisons can only be speculative as there were a large number of differences between the information provided in the Study 2a and 2b questionnaires.

There were two areas in which the information of Study 2a (energy reduction) differed from the information of Study 2b (load shifting). The first is that the energy reduction information (Study 2a) referred to the individual benefits of using the HEMS to track their energy consumption (e.g. “This awareness could help you to reduce the amount of energy you use”). The second difference is that the technology was related to reaching national emission targets (e.g. “help the UK to reach its targets for 2030”). In contrast, the load shifting information (Study 2b) referred directly to a need for cooperation in achieving a collective goal (e.g. “if enough people reduce their electricity use at the same time…”). Then, rather than help with emission targets, it explicitly referred to how load shifting could save the householder money (e.g. “how could real time pricing help you to save money?”).

Because of the differences in information, Study 2a had a collective goal with advertised personal benefits (rewards) and Study 2b has a personal goal with advertised collective benefits (rewards). Therefore, there will have been differences between the studies in terms of the salience of different goals. It would be of interest to explicitly explore the potential for different framing of the technologies further, particularly around different energy management related goals, such as personal goals of saving money versus benefiting the collective, or consuming less energy versus shifting energy use patterns.

5.10.4 Limitations

There are some limitations to the present studies. For example, only quantitative responses to the HEMS were measured. As such, there are limitations to the insights that can be gained. For instance, there may have been aspects of the HEMS or load shifting that the individual accepted, whilst at the same time rejecting other aspects (e.g. accept the idea of being told their consumption, but reject the idea of having their consumption information shared with their neighbours). As the questionnaires of Studies 2a and 2b did not enable the participant to indicate these distinctions, it is not possible to know if their questionnaire responses were driven by only one aspect of the technology that was perceived as being most important, or an averaged, overall perception of the different aspects. Further studies would need to explore the acceptability of the different aspects of such technologies, such as privacy concerns or usability concerns (e.g. Efthymiou & Kalogridis, 2010).

A further limitation in the present study due to the sample. For instance, the direct experiences of energy technologies were not measured. As noted by Hargreaves et al. (2010), often those who participate in energy technology studies are those who are already interested in reducing their energy consumption and on an energy "journey". In Studies 2a and 2b it was assumed they would not have had experience with the HEMS. It was not considered, however, that they may have had experience using other energy management technologies, such as in home displays, or energy management mobile phone applications. Such experiences may have lead individuals to feel more competent (and motivated) in using further energy management technologies, particularly in comparison to an individual who has never engaged with an energy management tool before. With such future orientated questionnaires, it is perhaps important to understand the participants' frame of reference when making judgements. As such, participants' previous energy management strategies and use of energy management technologies used should be asked.

It is also noted, that whilst efforts were made to seek a population sample (i.e. not a student sample) representative of UK householders (by using university staff email lists and social media sites), other biases may have been introduced. For example, there was a high level of participants reporting educational achievements as being at doctorate or higher. This may limit the generalisability of the findings to members of the population who do not possess doctorate degrees.

5.10.5 Future Research

Studies 2a and 2b offer a number of future avenues of research. For example, routinized household behaviours, and the personal goals associated with household energy consumption, are being identified as potential barriers to adoption of demand side management technologies and behaviours (Goulden et al., 2014). Therefore, the potential for the influence of household goals to be reduced when individuals consider their intention to use smart grid technologies, as suggested in Studies 2a and 2b, offer a promising avenue of future research.

The information used in the questionnaires of Studies 2a and 2b, may have had two framing effects, which might have influenced participants' perceptions of the HEMS. The energy reduction frame of Study 2a (i.e. "help the UK to reach its targets for 2030"), and the load shifting frame of Study 2b (i.e. "how could real time pricing help you to save money") created the intended behaviour framing, however, there were also differences in the incentive offered to engage in the behaviour. In Study 2a the incentive was benefiting the collective, whereas in Study 2b the incentive was saving money. The design of the studies meant it was not possible, statistically or qualitatively, to compare the effects of these different frames, as there were too many differences in the questionnaire information between the studies. Therefore, it was not possible to distinguish between the potential influence of the behaviour frame from the potential influence of the incentive frame on participants' perceptions and *Intention to Use* the HEMS. Exploring the influence of the questionnaires' information framing of the HEMS information, therefore, was identified as the next research question within the PhD.

5.10.6 Implications

If the UK and European governments, and network operators intend to facilitate more involvement from residential consumers in the efforts to reduce energy consumption and shift peak demands (see Chapter 3), then they will need to develop the policies and the infrastructure to enable consumers to gain more insight into their energy use. Not only this, but they will need to then motivate consumers to engage and respond to the new electricity information (e.g. peaks in demand). Wallenborn et al (2011), for instance suggest policy makers and energy networks need to be contributing to the development of a new "culture of energy" wherein consumers view the energy they consume as "precious" (p. 147), and users adapt their energy practices accordingly. Similarly, Goulden et al. (2014) suggested two personas of household energy users, the "energy consumer" and the "energy citizen". The energy consumer is passive and does not reflect on their energy usage. In contrast, the energy citizen is more active and has energy concerns at the surface of their thinking.

As highlighted in Chapter 3, this need for "energy citizens" to interact with the smart grid, and take responsibility (or co-responsibility) for load management, offers a specific example of how smart technologies, in cities and households, intend to empower users and increase their participation within the smart city strategies i.e. create smart citizens. Interviewees of Study 1 discussed the need for citizens to share the goals of the smart city as part of citizens taking responsibility for the development of their city. The findings of Studies 2a and 2b supported this argument by showing that the internalisation of a collective goal influences reduces the influence of more individualistic concerns. As the internalisation of a goal is considered an important factor within psychological empowerment (Menon, 1999), this finding also supported the importance of empowerment within the discussions of smart citizens. Therefore, inspiring users to pursue a collective goal, through the use of the technology, should be considered within policy for nation-wide technology deployment and by technology designers.

In relation to the smart citizen discussions of Study 1, the fact that the *Home Relevance* factor was such a strong predictor of *Intention to Use* the HEMS does not bode well for the view expressed by the interviewees that citizens need to transcend their self-interest in order to act for the collective benefit. The influence of *Home Relevance,* highlighted a dominance of an individualistic focus in participants' considerations of the HEMS. However, the *Environmental Concern* being a significant predictor in Study 2b suggested that transcendent, pro-environmental beliefs could positively influence *Intention to Use* the HEMS. In addition, the *Goal Internalisation* finding supported the argument that citizens need to be sharing the goals of the smart city in order to take responsibility for achieving sustainability. Indeed, the findings suggested that sharing a goal might undermine the more individualistic concerns of *Home Relevance.* As outlined, the framing, which would promote self-transcendent and shared goal considerations, was explored further in Study 3.

5.10.7 Conclusions

The findings of Studies 2a and 2b confirm that *Perceived Usefulness* is an important predictor of *Intention to Use* for HEMS. Furthermore, they indicated that the more consistent a smart grid technology's functions are with an individual's household energy goals (i.e. the greater the perceived *Home Relevance*), the more they perceive the technology as useful and the more they will intend to use it. However, it would appear that an internalisation of national energy targets (which leads people to consider the value of the technology in pursuing a shared, collective goal) reduces the influence of perceived *Home Relevance* on intentions to use the technology. Therefore, whilst qualitative studies have indicated the importance of home energy goals (Paetz et al., 2012), and the conflict between personal goals and environmental protection goals has been discussed (Selvefors et al., 2015), the findings of Studies 2a and 2b have provided a quantitative model in support of these arguments.

Concern of the environment increased perceptions of the usefulness of the HEMS in Study 2b, but not 2b. This suggests differences in the information may have led to different predictors influencing intentions to use. Further research into the framing of the information and its influence on acceptance of the HEMS was identified as a further research question to be explored in Study 3.

Chapter 6: Study 3

Goal-framing the Smart Energy Devices

6.1 INTRODUCTION

In terms of predicting the usage of the HEMS, in both studies 2a and 2b the internalisation of the normative goal of UK energy targets was a significant negative moderator of the more individualistic concerns of home relevance. This suggested that a shared, collective goal may influence personal energy goals when an individual is forming their intention to use a HEMS. This suggested a potential goal-framing effect. Goal-framing theory (Lindenberg & Steg, 2007) has been used to explore the effect of different goals on people's self-interested and normative behaviour (Keizer, Lindenberg, & Steg, 2011; Liberman, Samuels, & Ross, 2004). Therefore, the third study reported in the following chapter sought to explore and compare the effects of the goals of monetary savings (self-interested, gain goal) and environmental protection (collective, normative goal) on perceptions of load shifting and the HEMS and intentions to load shift and use the HEMS. Goal-framing theory will now be introduced, followed by how it can be related to load shifting behaviour.

6.1.1 Goal-framing Theory

Goals are desired outcomes from a particular behaviour. An activated goal (i.e. a focal goal) is argued to activate goal-relevant knowledge structures (i.e. the means for goal achievement; Gollwitzer & Bargh, 1996; Locke & Latham, 2013) and motivate the initiation and persistence of goal-directed behaviours (Deci & Ryan, 2000). Individuals can possess multiple, heterogeneous goals at one time. However, whilst multiple goals can be active, Lindenberg and Steg (2007) argue that there will be a dominant goal-frame (Sun & Frese, 2013; Unsworth, Yeo, & Beck, 2014). They argue that there are three superordinate and inclusive goals that vie for dominance. The suggested superordinate goals are hedonic, gain, and normative. The goal that becomes dominant will "frame" the individuals' cognitive processing and actions. As a result of this goal-framing, related knowledge and attitudes may become more cognitively accessible, certain aspects of their situation may become more or less salient, and different alternative actions come under consideration (Lindenberg, 2001; Lindenberg & Steg, 2007). At the same time, the non-dominant goal-frames become subordinate and have less influence on the individuals' cognition and evaluations. Although, the non-dominant goal-frames may still exert some background influence that then either strengthens (if the goals are compatible) or weakens (if the goals are incompatible) the dominant, focal goal (Lindenberg & Steg, 2007).

According to GFT, when a hedonic goal-frame is dominant it will activate one or more sub-goals related to achieving a more positive affect (or avoiding a negative affect) and are often focused on the immediate situation (i.e. to "feel better right now"). The individual may then be motivated to seek direct pleasure, self-esteem improvements or excitement, and avoid expending effort, unpleasant events, or negative thoughts. As such, aspects of the individual's situation that have the potential to increase or decrease their pleasure and affect their mood will become more salient to the individual. Alternatively, a gain goal-frame will activate sub-goals related to maximising personal resources (e.g. money, time etc.) and may relate to short, to medium term goals (i.e. "to guard and improve one's resources"; Lindenberg & Steg, 2007, p. 119). Accordingly, threats and opportunities to the individual's resources will become more salient to the individual, and they will be motivated to engage in behaviours that lead to the achievement of gains, the avoidance of loss, or an increase in the efficiency of their resources. Finally, a normative goal-frame will activate sub-goals relating to what the individual perceives they ought to do (i.e. "to act appropriately"), with the outcomes often being long term and related to group (collective) goals (Lindenberg, 2008; Lindenberg & Steg, 2007). Therefore, what the individual will consider they ought to do will become salient to the individual. The appropriate action is either defined by the self, or by perceptions of what others believe would be appropriate.

As noted above, goals can conflict (Lindenberg, 2008; Lindenberg & Steg, 2013). It may be that striving for normative goals conflict (either consciously or unconsciously) with gain goals (i.e. having to expend more time and effort by walking) and/or hedonistic goals (i.e. not being in the mood to walk). For example, studies have found that concerns for gain tend to displace concerns for norms as the cost of the normative behaviour increases (Bamberg & Schmidt, 2003; Diekmann & Preisendörfer, 2003; Gatersleben, Steg, & Vlek, 2002). This is discussed as the "low-cost hypothesis" of normative behaviour (Kirchgässner, 1992). However, if the cost of the normative goal is perceived as low, the normative goal may displace the hedonistic and/or gain goals. This is more likely if pursuing the gain goal threatens achieving the normative goal. Therefore they may choose not to drive in order to help reduce air pollution (Lindenberg, 2000; Spence, Leygue, Bedwell, & O'Malley, 2014).

Despite low-cost normative goals having the ability to displace hedonistic and/or gain goals, normative goals are the most vulnerable to displacement. It is suggested that self-interested goals are more cognitively accessible than normative goals and are considered within GFT to be *a priori* the stronger goal-frames. In contrast, access to normative goals is more easily reduced (Lindenberg & Steg, 2013). For instance, even a small number of people deviating from a social norm (such as littering) can undermine the feeling in others that the norm needs to be adhered to (Cialdini, Reno, & Kallgren, 1990). Therefore, normative goals need clear support from external social cues and feedback to promote their importance compared to hedonistic or gain goals (Keizer et al., 2011).

The dominance of a goal-frame can be triggered automatically by internal or external stimuli and the goal-frame can be influenced by priming effects. As such, experiments have been able to manipulate the activation of different goal-frames. For example, semantic priming was used for a social dilemma game. When the game was labelled as the "Wall Street game" in order to trigger a gain goal-frame, only 31 percent of participants cooperated with the other player. When the same game was labelled "community game" in order to trigger a normative goal-frame, 66 percent of participants cooperated (Liberman et al., 2004). This experiment suggests that semantic priming can influence goal-frame activation, which in turn influences whether subsequent behaviour is self-interested or cooperative.

6.1.2 Goal-framing and Load Shifting

In terms of environmental behaviours, acting in a way that is the least effort and/or most gainful to the individual in the short term (e.g. using a car), often has negative consequences for the environment or society (e.g. increased air pollution). In contrast, acting in a way which is appropriate and normative (e.g. not littering), is often less detrimental to the collective (e.g. cleaner environments). Therefore, pro-environmental behaviour is the result of multiple goal considerations, such as cost savings (gain) or environmental concerns (normative), which are in competition to be the focal goal-frame. (Lindenberg & Steg, 2007, 2013). Normative considerations have been found to be positively related pro-environmental behaviours (Czajkowski, Kądziela, & Hanley, 2014; Gärling, Fujii, Gärling, & Jakobsson, 2003; Schultz & Zelezny, 1998), whilst gain considerations is argued to relate to more self-interested behaviours (e.g. Lindenberg & Steg, 2007). Therefore, normative goals may lead to more environmentally beneficial behaviours than hedonistic and/or gain goals would (Lindenberg, 2008; Lindenberg & Steg, 2013), although pursing gain goals can sometimes also have environmental benefits (e.g. Dóci & Vasileiadou, 2015).

Load shifting behaviour has the potential to help with pursuit of both normative and gain goals. Changing energy consumption patterns to avoid peak times (or “fill in” trough times) has the potential for both collective, environmental benefits and individual, money saving benefits. Whilst this may suggest that both those who wish to save money and those who wish to act pro-environmentally will be motivated to load shift, it may be that extrinsic rewards actually undermine intrinsic motivation. For instance, Schwartz, Bruine de Bruin, Fischhoff, and Lave (2015) investigated willingness to sign up to a load shifting scheme. They found that participants’ were less willing to enrol in the scheme when the money saving aspects of load shifting were emphasised, compared to when the environmental benefits were emphasised. Critically, for those who held pro-environmental beliefs, the difference in willingness between the two conditions was greater than for those who did not hold pro-environmental beliefs. Furthermore, they found that those in the monetary framed condition who scored higher for pro-environmental beliefs indicated even lower willingness to participate compared to those in the monetary framed condition who had scored lower for pro-environmental beliefs.

The study by Schwartz et al. (2015) suggests that when a task, such as load shifting, is both extrinsically rewarding (saving money) and intrinsically rewarding (acting in line with pro-environmental values), then emphasising the extrinsic reward, can undermine the intrinsic motivations, particularly for those with already formed pro-environmental beliefs. This supports Bolderdijk, Steg, Geller, Lehman, and Postmes (2013) who found that framing a behaviour (getting their tyres checked) as being environmentally beneficially, compared to financially beneficial, increased the behaviour. Appealing to individuals' finances is a common strategy used within energy reduction and load shifting campaigns (Evans et al., 2013). Taken together, however, these studies suggest that doing so may be less effective at motivating behaviour compared to values and may even undermine intrinsic motivations.

Considering the influence of emphasising either monetary savings or environmental benefits on participants' willingness to engage in load shifting; how energy saving devices, such as the HEMS, are presented and explained to consumers may be an important factor in smart energy technology acceptance. One of the differences between the information in the Study 2a and 2b questionnaires was that the information about energy reduction (Study 2a) focused on the need to help reduce energy consumption in the UK. The information on load shifting, however (Study 2b), also emphasised how load shifting could save the householder money. Therefore, there were two potential framing effects; a behavioural one (energy reduction vs load shifting) and a motivational one (normative vs gain).These framings may have differently affected the perceptions of the HEMS (Lindenberg & Steg, 2007, 2013; Schwartz et al., 2015).

It is possible, therefore, that how the HEMS was framed in Studies 2a and 2b may have influenced which goal-frames were activated, and subsequently affected how participants perceived the technologies. The present study, therefore, aimed to explore the acceptance of smart energy technologies using goal-framing theory in order to more rigorously explore the effect of the goal-frame on perceptions and acceptance of the HEMS. It was reasoned that framing the HEMS in terms of a money saving device (i.e. a gain goal), should lead to the activation of goals associated with acting within one's own best interests by minimising the financial costs to the self and maximising the financial benefits. Conversely, framing the HEMS in terms of a technology which, when used, can contribute towards a UK energy reduction target (normative goal), should lead to the activation of goals associated with acting in a way which benefits the collective (i.e. society). Therefore, there were two research questions (RQ):

- **RQ1**: does the goal that is used to frame load shifting and the HEMS affect individuals' perceptions of load shifting behaviour and the HEMS?
- **RQ2**: does the goal that is used to frame load shifting and the HEMS influence the factors that predict individuals' intention to use the HEMS?

6.1.2.1 Hypotheses for Research Question 1

1) There will be a difference between goal-frame condition in the responses the TAM2 factors.

2) There will be a difference between goal-frame conditions in *Intention to Use* the HEMS.

3) There will be a difference between the goal-frame conditions in *Intention to* load shift.

6.1.2.2 Hypotheses for Research Question 2

The gain goal condition was intended to prime pragmatic considerations of the personal utility of the HEMS, which would make the cognitive instrumental factors of the TAM2 salient (i.e. information relating what the system is capable of doing and what one needs to do in order to attain one's goal; Venkatesh & Davis, 2000). Equally, the costs and benefits of the HEMS would be evaluated in terms of necessary effort involved. The greater one perceives their competence in managing their energy consumption to be, the less effort they will perceive it to cost them (Menon, 2001). As such, it was hypothesised that:

4) In the Gain Goal condition, the *Perceived Usefulness* would mediate the positive effect of the cognitive-instrumental factors of the TAM2 (*Home Relevance*, *Perceived Ease of Use, Result Demonstrability,* and *Quality of Output)* on *Intention to Use* the HEMS

5) In the Gain Goal condition, *Perceived Usefulness* would mediate the positive effect of *Perceived Competence* (to manage one's energy consumption) on *Intention to Use* the HEMS.

In contrast, it was intended that the normative goal would prime considerations of the broader social worth of the HEMS, thereby making the social influence processes of the TAM2 more salient (i.e. the social forces influencing an individual as they form a decision to accept or reject a technology). As such, it was hypothesised that:

6) In the Normative Goal condition, *Perceived Usefulness* would mediate the positive effects of the social influence processes of the TAM2 (*Social norms, Voluntariness, and Image*) on *Intention to Use* the HEMS.

Furthermore, as normative goals are argued to be a priori weaker than gain goals, they require support from other social forces, such as significant others, prominent examples, sanctions and values (Lindenberg & Steg, 2007). Therefore, environmental values may have become salient in a normative goal-frame. As such, it was further hypothesised that:

7) In the Normative Goal condition, *Perceived Usefulness* would mediate the positive effect of *Environmental Concern* and *Environmental Citizenship* (being predicated on the possession of environmental values; Stern, 2000) on *Intention to Use* the HEMS.

The goal of reducing UK energy targets is a shared, collective goal, the internalisation of which requires the individual to share the collective values (Menon, 2001). Therefore, the internalised goal may be activated by the normative goal-frame and support the individuals' *Intention to Use* the HEMS. In addition, the *Perceived Control* over the energy used in the neighbourhood factor is social in nature as it refers to the extent to which the individual feels they have influence over others (Menon, 1999, 2001). The more control individuals perceive themselves as having over the energy usage in their neighbourhood, the more agency the individual will feel (Ajzen & Madden, 1986; Armitage & Conner, 1999). As such, it was hypothesised:

8) In the Normative Goal condition, *Perceived Usefulness* would mediate the positive effect of psychological empowerment variables of *Goal Internalisation* and *Perceived Control* on *Intention to Use* the HEMS.

6.2 METHOD

Study 3 received ethical approval from the University of Sheffield's Department of Psychology Ethics Committee.

6.2.1.1 Generating the Information for the Informed Questionnaire

An approach which informs the participant of the context and nature of the technology was chosen for the reasons outlined in the materials section of Study 2a (Chapter IV) and will not be fully outlined here. Essentially, the technologies and scenarios that are of interest to this research are not yet mainstream or within the public-sphere (Raimi & Carrico, 2016). Therefore, peak demand, load shifting and the HEMS had first to be explained to the participants before their perceptions relating to these topics could be measured.

Information for the questionnaire in the present study was created using the validated load shifting and HEMS information from Study 2b. It was judged by the researcher that the information would not need to be validated by experts as the concepts were the same as in the validated information of Studies 2a and 2b. Therefore there was confidence that the load shifting information presented in the questionnaire was an accurate potential future scenario for household energy management, and that it was presented in a neutral, non-leading form (this was also checked in the pilot stage of the study, see below). The questionnaire flow can be seen in Figure 10 (the full questionnaire can be seen in Appendix J). The questionnaire was intended to take around 10 minutes to complete.

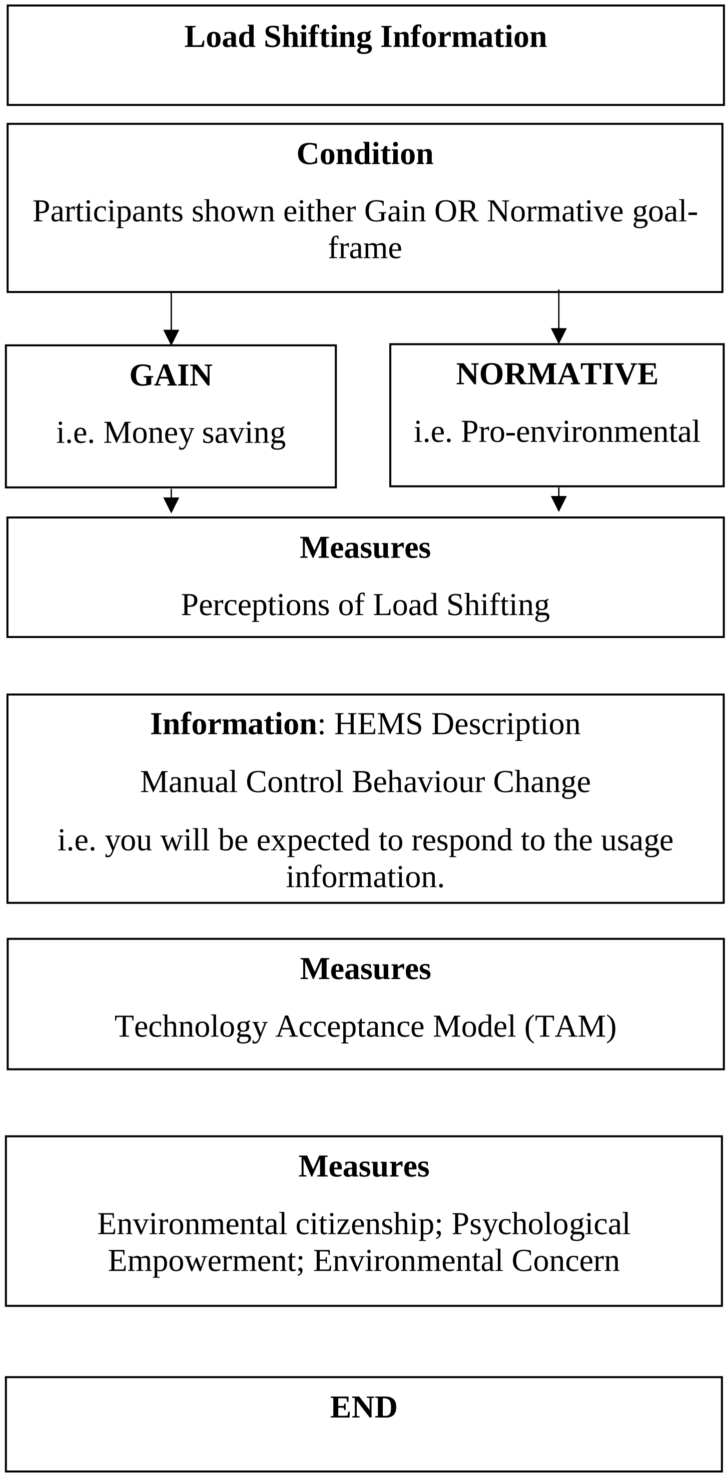


Figure 10. Diagram outlining the questionnaire flow for study 3.

6.2.1.2 The Goal-frame Manipulation

There were two experimental conditions with a goal-framing manipulation. One condition had information that was intended to activate a Gain Goal-frame, whilst the other condition had information that was intended to activate a Normative Goal-frame. In each condition, the information explaining load shifting, peak demand, and the HEMS technology was identical except for the last three paragraphs. The last three paragraphs were altered to create the goal-frame manipulation for the respective condition and are shown in Table 25. The Gain Goal paragraphs explained to the participant how load shifting might save them money (thereby ostensibly activating concerns for personal resources). The Normative Goal paragraphs, on the other hand, explained how the UK government has greenhouse gas reduction targets and that by load shifting the participant would help to meet those targets (thereby ostensibly activating concerns for what one ought to do). The goal-framing paragraphs were phrased similarly and kept to near-equal lengths (131 words for the Gain Goal-frame, 135 words for the Normative Goal-frame) in order to control the amount of variation in the information presented to participants in each condition.

In both conditions, the information provided in the questionnaire focused on load shifting behaviour. The Normative Goal condition did explain the need for load shifting in terms of reducing greenhouse gas emissions, but this was from a UK target reaching perspective as opposed to an environmental protection perspective (as it was in the information of Study 2a). Focusing on load shifting reduced the number of energy related concepts in the information (compared to the information in Study 2a and Study 2b). Reducing the number of energy related concepts to consider, and reducing the required reading time through shortening the information would increase completion rates of the questionnaire. The shorter information would also increase the participants' focus on the part of the information with the goal-frame manipulation

Table 25. Information used for Goal-framing manipulation in each condition.

Gain Goal-framing	Due to this greater demand and extra generation, the price of the electricity goes up. This means electricity is more expensive when a lot of people are using it. A scheme called *real time pricing* will soon mean that the price you pay for your electricity will change as the level of electricity being used across your neighbourhood changes. For instance, at the times of peak demand in your neighbourhood, you would pay more for your electricity than at other times when there is less demand. Electricity would be cheaper for you if you, as a householder, could use your electricity at the times when other people in your neighbourhood are not. If you changed the times when you use your electricity, and avoided the peaks, then you would save money.
Normative Goal-framing	Due to this greater demand and extra generation, there is a large production of greenhouse gasses. Currently, the UK has a legally-binding target to reduce its production of greenhouse gasses by 34% by the 2020. A scheme called *real time information* will soon mean that householders will be able to see how much electricity is being used within their neighbourhood. For instance, you would be able to know if there is currently a peak in electricity demand or not within your neighbourhood. It would be beneficial for the UK if you, as a householder, could use your electricity at the times when other people in your neighbourhood are not. If you changed the times when you use your electricity, and avoided the peaks, you would help to reach the targeted reduction in greenhouse gas emissions.

6.2.2 Measures

For the HEMS, the attitudinal and value scales from Study 2a and Study 2b were used in the Study 3 and therefore will not be described in great detail again here. The scales used were the TAM2 (Venkatesh & Davis, 2000), Psychological Empowerment (Menon, 1999), Environmental Citizenship (Stern, 2000), Environmental Concern (measured by the NEP;

Dunlap et al., 2000), Attitude towards Use (Ajzen & Fishbein, 1980) and Intention to Use (Fishbein & Ajzen, 1975) scales. Whilst the TAM2 factors did not perform well in Studies 2a or 2b as predictors of *Intention to Use* the HEMS, it was decided they would be used again to confirm (or challenge) the findings of Studies 2a and 2b.

Attitude towards the load shifting behaviour and intention to load shift were also measured using modified Ajzen and Fishbein (1980) attitudinal scale and Fishbein and Ajzen (1975) intention scale (F. D. Davis, 1989). Demographic questions included age, gender, highest level of attained education, and property ownership or rental. As there was a manipulation element to this study in terms of which information the participant would receive, a manipulation check was added at the end of the questionnaire which asked participants what they considered the aims of the study to be.

The same demographic information provided by participants in Study 2a and Study 2b was again used in this study. In addition, gender was requested and participants were asked to enter age was as a numerical value (as opposed to categorical).

6.2.3 Pilot study

Prior to the main study, the questionnaire was piloted on a small opportunity sample (n=5; mean age= 36) from within the Department of Psychology, University of Sheffield. Participants were sent the questionnaire and asked to complete it in their own time. Written feedback was invited from the participants regarding any issues with the survey that they had and whether they felt the information had been leading them in order to influence their responses. Participants were asked “Did you feel any of the information was trying to influence your responses to the questions in any way?” and, if they did, to then “describe as best as you can, in what way you felt influenced”. None of the participants reported feeling influenced by the information. As a result of the feedback, some small alterations were made to the information to enhance the clarity, for example, the sentence: “*Smart appliances would mean that if you had a smart washing machine…*” was altered to “*An example of a smart appliance could be a washing machine…*”.

6.3 MAIN STUDY

6.3.1 Participant Recruitment

Participants for the main study were recruited through an international, online participant pool called ‘Prolific Academic’[5]. Participation in the questionnaire was limited to residents of the UK as the load shifting information was UK specific. UK participants were 26% of the Prolific Academic participant pool, which is around 1200 people (as of 01/08/2015). The study was listed on the Prolific Academic website with the title “When shouldn’t we use electricity?” and an approximate completion time of 15 minutes was indicated.

The questionnaire was accessed online by following a link from Prolific Academic to a survey designed using Qualtrics (see Qualtrics.com). Each participant was paid £2.50 upon completing the questionnaire. The questionnaire was made available on Prolific Academic from the 29th of July, 2015 and was closed on the 5th of August, 2015. All participants were

[5] http://prolific.ac/

fully debriefed on the nature of the goal-framing manipulation once they had submitted their questionnaire.

6.3.2 **Participants**

In total, 425 participants started the questionnaire of which 409 completed it (96% completion rate). Of these 409 questionnaires, 2 were not used as they had been completed in less than 3 minutes, which suggests the participant would not have given the information enough attention in order for them to give an informed response. Therefore there were a final N of 407 respondents, with a total of n = 206 respondents in the Gain Goal condition and n = 201 respondents in the Normative Goal condition.

6.3.2.1 Data Cleaning

In the Gain Goal condition where were 6 cases with missing data, and 15 missing data points. Little's MCAR test (Little, 1988) was used to distinguish between Missing at Random (MAR) and Missing Completely at Random (MCAR) data. The chi-square test was non-significant (χ^2 (1372) = 1289.14, p=.95). Therefore, the data was MCAR and does not reflect any systematic response bias. In the Normative Goal condition where were 9 cases with missing data, and 11 missing data points. Little's MCAR test (Little, 1988) was used. The chi-square test was significant (χ^2 (944) = 1084.83, p=.001), suggesting that data was not MCAR and so could be MAR or missing not at random (MNAR). Inspection of the missing data points, however, suggested no pattern to the missing data, and there was no theoretical reason for some of the participants to not respond to some of the items (particularly as they had completed the rest of the scale). Therefore, data was assumed missing at random (MAR).

In order conserve as many of the cases as possible (and maintain sample size), multiple imputation was used to estimate and replace the missing values. As the statistical software PROCESS cannot analyse multiple data sets, one imputed dataset was generated. SPSS (version 21) was used to conduct the multiple imputation (Yuan et al., 2012). All missing data were successfully imputed.

6.3.2.2 Influential Outliers

Upon running the assumptions checks for the three regression models in each condition (reported below), a multivariate outlier was identified in the Normative Goal condition. In the final (moderated) model, a case had a Mahalanobis distance of 34.86 and a Cook's distance of *Cooks's D* = 1.13. The Mahalanobis value exceeded the critical value for five predictors (X^2 = 20.52 at the p = .001 level) and the Cook's distance was greater than 1, which indicated it had a large influence on the model. However, a comparison of the moderated model with and without the case showed only small differences to the effect sizes. Furthermore the case was not an outlier for the other tested models, therefore the case was not deleted. There were no influential outliers identified in the models for the Gain Goal condition.

Table 26. Response frequencies: demographical information (Study 3).

	Gain Goal		**Normative Goal**	
	Frequency	Percentage	Frequency	Percentage
Gender	203		198	
Male	86	42.36	79	39.90
Female	116	57.14	119	60.10
Prefer not to say	1	0.49	0	0
Property Ownership	205		198	
Renting the property	92	44.88	94	47.47
Own the property	86	41.95	78	39.39
Other	27	13.17	26	13.13
Property Type	204		198	
Detached	33	16.18	42	21.21
Semi-Detached	73	35.78	55	27.78
Terrace	50	24.51	52	26.26
Flats	48	23.53	49	24.75
Educational Attainment	205		199	
GCSE/O-level	19	9.27	23	11.56
A/AS level	69	33.66	49	24.62
University Degree	75	36.59	89	44.72
Master's Degree	30	14.63	31	15.58
Doctorate Degree	5	2.44	5	2.51
Other	7	3.41	2	1.01
	Mean	**SD**	**Mean**	**SD**
Age	29.57	9.62	30.01	9.83

6.3.2.3 Randomisation Check

The key demographic information for participants in each condition is shown in Table 26. In order to check for the homogeneity of participants in the two goal-framing conditions, statistical differences in the participants' demographic information between conditions were explored using Chi Square (X^2) and independent samples t-tests. There was no statistically significant difference between groups in terms of gender, X^2 (2, N = 401) = 1.27, p = .53; type of property, X^2 (3, N = 402) = 3.57, p = .31, proportion of home-owners vs. renters, X^2 (3, N = 403) = 3.10, p = .86; education level, X^2 (5, N = 404) = 7.63, p = .18; or age, t(398) = .46, p =.65.

6.3.2.4 Assessing differences on psychological variables, citizenship, and values

A bootstrapped one-way ANOVA was used to assess differences between the Gain Goal condition and the Normative Goal condition in the participants' reported *Goal Internalisation, Perceived Control, Perceived Competency, Environmental Citizenship, and Environmental Concern.* The means, standard deviations and the effect size and significance statistics are shown in Table 27. There were no significant differences between conditions on any of the factors. This suggested that on average, the participants in the Gain Goal condition and the Normative Goal condition had (equally) internalised the UK energy goals, perceived themselves as competent enough to use the HEMS, were somewhat engaged with environmental issues, felt general concern for the environment, and felt themselves to be unable to control their neighbourhood's energy usage

Table 27. Between group comparison for psychological empowerment, environmental citizenship, and environmental concern (Study 3).

Subscale	Condition: Gain Goal Mean (*SD*) *n*=206	Normative Goal Mean (*SD*) *n*=201	F	*p*
Goal Internalisation	4.13 (1.08)	4.15 (1.08)	.06	.81
Perceived Control	2.41 (1.33)	2.39 (1.20)	.02	.89
Perceived Competency	4.63 (.95)	4.62 (.95)	.03	.86
Environmental Citizenship	8.81 (1.87)	8.59 (1.72)	1.47	.23
Environmental Concern	3.71 (.54)	3.72 (.53)	.04	.84

Df=1 Error= 404. Scales: Goal Internalisation, Perceived Control, and Perceived Competency (1-6); Environmental Citizenship (7-14); Environmental Concern (1-5)

6.4 RESULTS

First the between group differences in the perceptions of the HEMS are presented, followed by the predictive models for *Intention to Use* the HEMS in the Gain Goal condition and then the Normative Goal condition.

6.4.1 Perceptions of Load Shifting and the HEMS

In order to test if the different framing of the information had an influence on participants' of load shifting attitudes and intentions, and perception of the HEMS (research question 1) a bootstrapped MANOVA was used to assess the between group differences for the Load Shifting and TAM2 responses.

6.4.1.1 Assumption Checks for MANOVAs

Multivariate checks of normality, homogeneity and linearity indicated no violations of assumptions. Mahalanobis and Cook's *D* indicated no influential outliers for each of the MANOVA models. The dependent variables correlations with each other were assessed. It is important for maintaining the power of the analysis that the dependent variables are correlated. Equally, it is important to avoid multicollinearity with dependent variables correlating too highly (Field, 2009). For the Load Shifting and TAM2 items, all dependent variables were significantly correlated with each other (see Appendix H), except for *Voluntariness* in the TAM2 model, which had no significant correlations with *Attitude towards Use*, *Intention to Use, Home Relevance* or *Subjective Norm.* All dependent variables had Pearson's $r < .09$ indicating no violation of the multicollinearity assumption.

6.4.1.2 Results for Perceptions of Load Shifting

There was a statistically significant main effect of the Goal-framing condition on the participants' perceptions of the load shifting, $F(3, 402) = 11.59$, $p < .001$; Wilk's $\Lambda = .92$, partial $\eta^2 = .08$. Inspection of the between subject effects (see Table 28), indicated that condition had a statistically significant influence on the participants' *Attitude towards Load Shifting* the HEMS ($p<.001$). This suggests that the participants in the Normative Goal condition had a more positive attitude towards load shifting than participants in the Gain Goal

Table 28. Between group comparisons for load shifting perceptions (Study 3)

Subscale	Condition: Gain Goal Mean (s.d.) *n*=206	Condition: Normative Goal Mean (s.d.) *n*=206	F	*p*	Partial η2
Attitude towards load shifting	4.61 (1.34)	5.05 (1.15)	12.27	**.00**	.03
Convenience of load shifting	3.74 (1.42)	3.96 (1.29)	.52	.47	.00
Intention to Load shift	4.83 (1.21)	4.58 (1.21)	4.76	**.03**	.01

Note: *df*=1 Error= 404; Bonferroni correction applied: *a*= .017. Item scales 1-7

condition did. There was no statistically significant difference between participants' *Intention to Load Shift* (after Bonferroni correction) or the *Convenience of Load Shifting*.

6.4.1.3 Results for Perceptions of the HEMS

There was a statistically significant main effect of the Goal-framing condition on the participants' perceptions of the HEMS, $F(10, 395) = 2.32$, $p = .01$; Wilk's $\Lambda = .95$, partial $\eta^2 = .06$. Inspection of the between subject effects (see Table 29), indicated that condition had a statistically significant influence on the participants' *Intention to Use* the HEMS ($p < .01$) and their perceptions of the HEMS' *Home Relevance* ($p < .001$). Reference to the means indicated that the participants in the Gain Goal condition had a more positive attitude towards using the HEMS, indicated a higher intention to use the HEMS and perceived the HEMS as being more relevant to their homes than the participants in the Normative Goal condition did. There were no statistically significant differences between participants' responses to the other TAM2 variables. This suggested that people in both conditions had an equally positive attitude towards the use of the HEMS, and perceived the HEMS as equal in terms of being useful, easy to use, voluntary, not affording prestige, providing good output, having demonstrable results, and being supported by people who influence their behaviour.

Table 29. Mean responses and between group comparison for TAM2 variables (Study 3)

	Condition				
Subscale	**Gain Goal Mean (s.d.) *n*=206**	**Normative Goal Mean (s.d.) *n*=207**	***F***	***p***	**Partial η2**
Intention to Use	5.81	5.42	9.31	**.00**	.02
	(1.14)	(1.44)			
Perceived Usefulness	5.82	5.65	2.69	.10	.01
	(.96)	(1.12)			
Perceived Ease of Use	5.52	5.47	0.27	.60	.00
	(.92)	(1.06)			
Voluntariness	5.45	5.31	1.94	.16	.00
	(1.05)	(1.00)			
Image	3.22	2.98	2.93	.09	.01
	(1.43)	(1.32)			
Home Relevance	5.31	4.85	13.78	**.00**	.03
	(1.13)	(1.35)			
Output Quality	5.36	5.21	2.35	.13	.01
	(.92)	(1.04)			
Result	5.51	5.34	2.86	.09	.01
Demonstrability	(.95)	(1.02)			
Subjective Norm	4.31	4.13	1.73	.19	.00
	(1.27)	(1.42)			
Attitude towards use	5.89	5.66	5.12	**.02**	.01
	(.96)	(1.10)			

Note: *df*=1 Error= 404; Bonferroni correction applied: *a*= .005. TAM2 item scale 1-7

Significant differences (a = .05) in bold.

6.4.2 Predicting Intention to Use the HEMS in the Gain Goal condition

6.4.2.1 Assumption Tests for the Regression Models

For all three regression models below, the inspection of the Mahalanobis distances and Cook's distances indicated no influential outliers in the models. Inspection of the predictors' correlation, VIF and tolerance values showed no multicollinearity within the models. There were no issues of non-linearity. Each model showed slight heteroscedasticity. The p-p plots of the standardised residuals and the histogram indicated that the residuals of the regression models had a normal distribution.

6.4.3 Augmented TAM2 Gain Goal condition

As in Study 2a and Study 2b, only the TAM2 predictors were entered in a simple mediation analysis first. The linear model for predicting *Perceived Usefulness* was significant $R^2 = .59$, $F(7, 198) = 41.38$, $p < .001$ and *Home Relevance* ($\beta = .44$, $p < .01$) and *Perceived Ease of Use,* ($\beta = .36$ $p<.01$) were significant predictors. The linear model for predicting *Intention to Use* the HEMS was also significant $R^2 = .69$, $F(8, 197) = 54.37$, $p < .001$, and *Home Relevance* ($\beta = .22$, $p<.01$), *Perceived Usefulness* ($\beta = .54$, $p<.01$), *Result Demonstrability* ($\beta = .13$, $p = .03$), and *Voluntariness* ($\beta = -.09$, $p=.04$) were significant predictors. The full results for the model with only the TAM2 predictors can be found in Appendix L.

The second model to be tested was the Augmented model, where the exploratory variables of *Goal Internalisation, Perceived Control, Perceived Competence, Environmental Citizenship,* and *Environmental Concern* were entered into a simple mediation analysis with the significant predictors from the TAM2 model.

The model coefficients for the Augmented model predicting *Perceived Usefulness* and the *Intention to Use* the HEMS can be seen in Table 30. The linear model for predicting *Perceived Usefulness* of the HEMS from the TAM2 variables was significant, $R^2 = .61$, $F(9, 196) = 34.35$, $p<.001$, as was the linear model for *Intention to Use* the HEMS, $R^2 = .69$, $F(10, 195) = 43.75$, $p< .001$. The Augmented model, therefore, was able to explain a slightly larger proportion participants' *Perceived Usefulness* and an equal proportion of their *Intention to Use* the HEMS (61% and 69% respectively) compared to the TAM2 (59 and 69% respectively).

As with the TAM2 model, *Perceived Ease of Use* (β = .38) and *Home Relevance* (β = .43) lead to greater *Perceived Usefulness* of the HEMS. In turn, the *Perceived Usefulness* of the HEMS predicted participants' *Intention to Use* it (β = .53). Inspection of the bias corrected confidence intervals (Table 31) shows that *Perceived Usefulness* mediated both the effects of the *Perceived Ease of Use* (.10 to .34) and *Home Relevance* (.10 to .41) on *Intention to Use* HEMS. *Home Relevance* also maintained its independent, direct positive influence on participants' *Intention to Use* the HEMS (β = .24). The participants' perceptions of *Voluntariness* still had a significant negative influence on their *Intention to Use* the HEMS (β = -.11). Perceptions of *Result Demonstrability* no longer had a significant influence on participants *Intention to Use* the HEMS.

Of the Augmented variables, only *Environmental Citizenship* had a significant influence in the model (β = .12), with greater *Environmental Citizenship* positively predicting greater *Perceived Usefulness* of the HEMS. The model was re-estimated without the non-significant predictors. The resulting estimates are shown in Figure 11.

Table 30. Model coefficients for Augmented TAM2 in the Gain Goal condition

		Consequent						
		Perceived Usefulness (*M*)				Intention to Use the HEMS (*Y*)		
Antecedent (X)		Std. Coeff. (β)	SE	p		Std. Coeff. (β)	SE	p
Perceived Ease of Use	*a*	.38	05	**.00**	c’	.04	.06	.51
Voluntariness		-.00	05	.97		-.11	.04	**.01**
Home Relevance		.43	.06	**.00**		.24	.06	**.00**
Result Demonstrability		.10	.06	.10		.10	.06	.07
Environmental Citizenship		.12	.05	**.02**		.07	.04	.12
Environmental Concern		-.02	.05	.75		.01	.05	.79
Goal Internalisation		.11	.06	.07		-.03	.05	.57
Perceived Control		-.07	.05	.18		-.02	.05	.73
Perceived Competence		-.04	.05	.41		.06	.05	.20
Perceived Usefulness (Mediator)		-	-	-	*b*	.53	.04	.00
Constant	i_1	.00	.04	1.0	i_2	.00	.04	1.0
		$R^2 = .61$				$R^2 = .69$		
		$F(9, 196) = 34.35$ $p < .001$				$F(10\ 195) = 43.75$ $p < .001$		

Standard Error (SE) estimated from a bias-corrected bootstrap sample of 10,000. Variables with p<.05 are emboldened. N=206.

Table 31. Estimates of the indirect effects of the Augmented TAM2 predictors on Intention to Use HEMS as mediated by Perceived Usefulness in the Gain Goal condition.

Antecedent	Std. Coeff. (β)	SE	Lower level CI	Upper level CI
Perceived Ease of Use	.20	.06	**.10**	**.34**
Voluntariness	-.00	.03	-.06	.05
Home Relevance	.23	.08	**.10**	**.41**
Result Demonstrability	.05	.05	-.05	.14
Environmental Citizenship	.06	.02	**.02**	**.12**
Environmental Concern	-.01	.03	-.06	.04
Goal Internalisation	.06	.04	-.01	.15
Perceived Control	-.04	.03	-.10	.01
Perceived Competence	-.02	.04	-.11	.04

Confidence intervals (CI) and Standard Error (SE) estimated from a bias-corrected bootstrap sample of 10,000. Lower and Upper CIs without 0 in their range are emboldened. N=206.

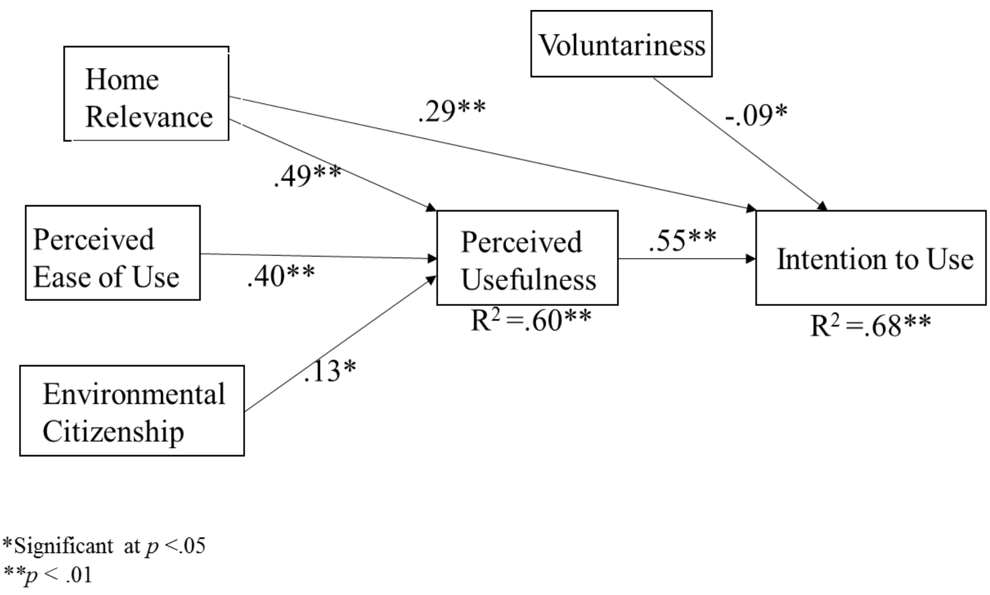


Figure 11. Augmented TAM2 variables predicting Intention to Use the HEMS in the Gain Goal condition.

6.4.4 Testing Goal Internalisation as a Moderator in the Gain Goal condition

Given the negative interaction effect observed in Study 2a and Study 2b, *Goal Internalisation* was entered as a moderator of *Home Relevance's* influence on *Intention to Use* the HEMS. The coefficients and significance values are shown in Table 32. The interaction term was not significant and no further analysis was conducted. As such, the Augmented model was the final model.

Table 32. Model coefficients for the Moderated Model in the Gain Goal condition

		Consequent						
		Perceived Usefulness (M)				Intention to Use the HEMS (Y)		
Antecedent (X)		Std. Coeff. (β)	SE	*p*		Std. Coeff. (β)	SE	*p*
Perceived Ease of Use	a	.40	.05	**.00**	c'	.09	.05	.10
Voluntariness		.01	.05	.84		-.09	.04	**.02**
Home Relevance		.49	.05	**.00**		.27	.06	**.00**
Environmental Citizenship		.13	.05	**.01**		.08	.04	.06
Goal Internalisation		-	-	-		.01	.04	.86
Goal Internalisation X Home Relevance		-	-	-		-.06	.04	.13
Perceived Usefulness (Mediator)		-	-	-	b	.53	.06	**.00**
Constant	i_1	.00	.04	1.0	i_2	.02	.04	.59
		R^2 = .60				R^2 = .68		
		F(4, 201)= 74.23 p < **.001**				F(7 198)= 61.43 p < **.001**		

Standard Error (SE) estimated from a bias-corrected bootstrap sample of 10,000.
Variables with p<.05 are emboldened

6.4.5 Predicting Intention to Use the HEMS in the Normative Goal condition

6.4.5.1 Assumption Testing for Regression Models

As in the Gain Goal condition, all model assumptions were met.

6.4.6 Augmented TAM2 Normative Goal condition

As in the Gain Goal condition, only the TAM2 predictors were entered in a simple mediation analysis first. The linear model for predicting *Perceived Usefulness* was significant, R^2 = .69, $F(7, 193) = 62.31$, $p<.001$ and *Home Relevance* (β = .56, $p< .01$) and *Perceived Ease of Use* (β = .43, $p < .01$), and *Result Demonstrability* (β = .14, $p = .02$) were significant predictors. The linear model for predicting *Intention to Use* the HEMS was also significant, R^2 = .71, $F(8, 192) = 58.62$, $p < .001$, with *Home Relevance* (β = .32, $p< .01$), *Perceived Ease of Use* (β = .15, $p = .02$), and *Perceived Usefulness* (β = .48, $p < .01$) were significant predictors. The full results for the model with only the TAM2 predictors can be found in Appendix L.

The Augmented model was then tested. The model coefficients can be seen in Table 34. The linear model for predicting *Perceived Usefulness* of the HEMS from the TAM2 variables was significant, R^2 = .69, $F(7, 193) = 60.41$, $p < .001$, as was the linear model for *Intention to Use* the HEMS, R^2 = .72, $F(8, 192) = 60.64$, $p < .001$. The Augmented model, therefore, was able to explain an equal proportion participants' *Perceived Usefulness* and a marginally greater proportion of *Intention to Use* the HEMS (69% and 72% respectively) than the TAM2 (69% and 71% respectively).

As with the TAM2 model, *Perceived Ease of Use* (β = .45) and *Home Relevance* (β = .52) lead to greater *Perceived Usefulness* of the HEMS. In turn, the *Perceived Usefulness* of the HEMS predicted participants' *Intention to Use* it (β = .45). Inspection of the bias corrected confidence intervals (Table 33) shows that *Perceived Usefulness* mediated both the effects of the *Perceived Ease of Use* (.08 to .35) and *Home Relevance* (.12 to .35) on *Intention to Use* it. *Home Relevance* (β = .30) and *Perceived Ease of Use* (β = .16) also maintained their independent, direct positive influencer of participants' *Intention to Use* the HEMS.

Of the Augmented variables, *Goal Internalisation* had a significant positive influence on *Intention to Use* (β = .13). In addition, participants' *Perceived Control* had a negative influence on the *Perceived Usefulness* of the HEMS (β = -.09). The model was re-estimated without the non-significant predictors. In the re-estimated model, *Goal Internalisation* was no longer significant, and so the model was re-estimated without it. The resulting estimates are shown in Figure 12.

Table 34. Coefficients for the Augmented TAM2 in the Normative Goal condition

Antecedent (X)		Consequent: Perceived Usefulness (*M*) Std. Coeff. (β)	SE	p		Intention to Use the HEMS (*Y*) Std. Coeff. (β)	SE	p
Perceived Ease of Use	a	.45	.05	**.00**	c'	.16	.05	**.00**
Home Relevance		.52	.05	**.00**		.30	.06	**.00**
Environmental Citizenship		-.02	.05	.66		-.02	.04	.70
Environmental Concern		.04	.05	.42		-03	.05	.55
Goal Internalisation		.09	.06	.10		.13	.05	**.02**
Perceived Control		-.09	.05	**.04**		.02	.04	.59
Perceived Competence		-.04	.05	.46		-.05	.05	.30
Perceived Usefulness (Mediator)		-	-	-	b	.45	.07	.00
Constant	i_1	.00	.04	1.00	i_2	.00	.04	.00
		$R^2 = .69$				$R^2 = .72$		
		$F(7, 193) = 60.41$ $p < .001$				$F(8, 192) = 60.64$ $p < .001$		

Standard Error (SE) estimated from a bias-corrected bootstrap sample of 10,000.
Variables with p<.05 are emboldened. N=201

Table 33. Estimates of the indirect effects of TAM2 predictors on Intention to Use HEMS as mediated by Perceived Usefulness in the Normative Goal condition

Antecedent	Std. Coeff. (β)	SE	Lower level CI	Upper level CI
Perceived Ease of Use	.20	.07	**.08**	**.35**
Home Relevance	.23	.06	**.12**	**.35**
Environmental Citizenship	-.01	.02	-.06	.03
Environmental Concern	.03	.04	-.05	.10
Goal Internalisation	.04	.04	.-01	.13
Perceived Control	-.04	.03	-.11	.00
Perceived Competence	-.02	.03	-.03	.03

Confidence intervals (CI) and Standard Error (SE) estimated from a bias-corrected bootstrap sample of 10,000. Lower and Upper CIs without 0 in their range are emboldened. N=201.

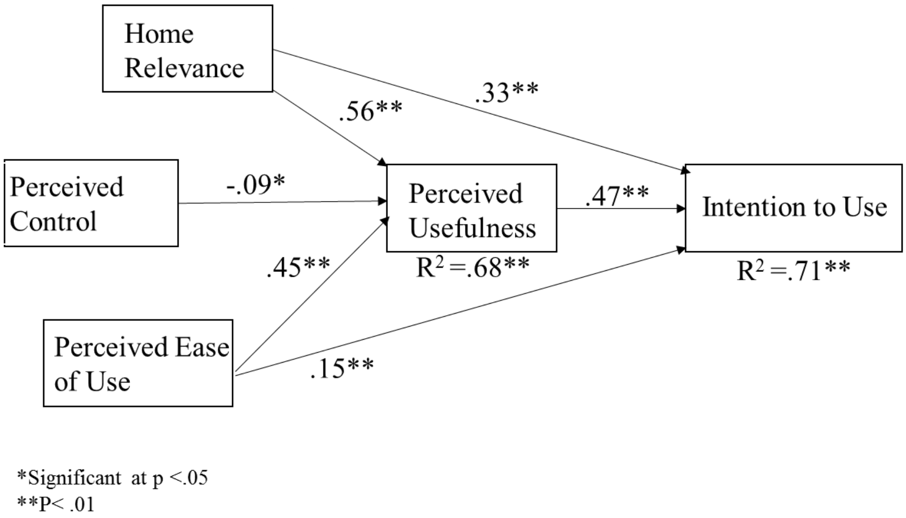


Figure 12. Augmented TAM2 variables predicting Intention to Use the HEMS in the Normative Goal condition.

6.4.7 Testing Goal Internalisation as a Moderator in the Normative Goal Condition

As shown in Table 36, *Goal Internalisation* and *Home Relevance* had a significant negative interaction (β= -.13). The moderation analysis shown in Table 35 indicates that at higher levels of *Goal Internalisation* (+1 *SD*), *Home Relevance* has a reduced (although still significant) influence on *Intention to Use*. This decrease in the effect of *Home Relevance* suggests that participants' perceptions of the relevance of the HEMS to their home had less influence on their *Intention to Use* the HEMS if they experienced higher internalisation of UK energy goals. The moderation model is shown in Figure 13.

Table 36. Model coefficients for Moderated TAM2 in the Normative Goal condition

		Consequent						
		Perceived Usefulness (*M*)				Intention to Use the HEMS (*Y*)		
Antecedent (X)		Std. Coeff. (β)	SE	*p*		Std. Coeff. (β)	SE	*p*
Perceived Ease of Use	***a***	.45	.04	**.00**	c'	.16	.05	**.00**
Home Relevance		.56	.05	**.00**		.29	.06	**.00**
Perceived Control		-.09	.04	**.04**		.01	.04	.72
Goal Internalisation		-	-	-		.10	.05	**.04**
Goal Internalisation X Home Relevance		-	-	-		-.13	.04	**.00**
Perceived Usefulness (Mediator)		-	-	-	*b*	.44	.07	.00
Constant	i_1	.00	.04	1.0	i_2	.07	.04	.10
		$R^2 = .68$				$R^2 = .73$		
		$F(3, 197)= 139.42$ $p < .001$				$F(6, 194)= 87.95$ $p < .001$		

Standard Error (SE) estimated from a bias-corrected bootstrap sample of 10,000. Variables with p<.05 are emboldened. N=201.

Table 35. Normative Goal condition: The conditional direct effect of Home Relevance on Intention to Use at values of Goal Internalisation.

Goal internalisation (*SD*)	Std. Coeff. (β)	SE	*p*	Lower level CI	Upper level CI
-1.00	.42	.07	**.00**	.29	.54
.00	.29	.06	**.00**	.17	.40
1.00	.16	.07	**.03**	.03	.30

Confidence intervals (CI) and Standard Error (SE) estimated from a bias-corrected bootstrap sample of 10,000. N.B. As the variables have been standardised, their mean values are 0.

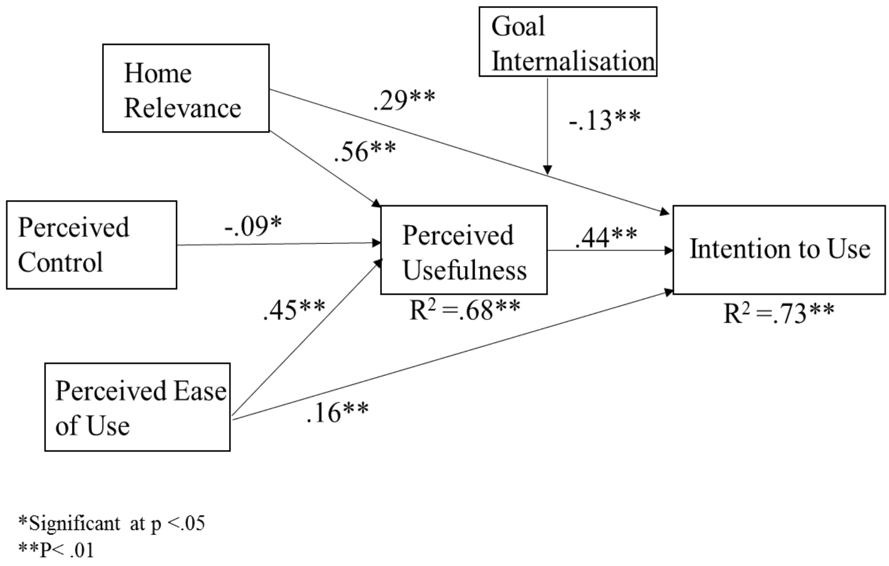


Figure 13. Moderated model for predicting Intention to Use the HEMS in the Normative Goal condition.

6.5 DISCUSSION

GFT was used to explore the effect of activating a gain goal-frame or a normative goal-frame on individuals' perceptions of load shifting and the HEMS. In a between participants design, participants in the Gain Goal condition had load shifting and the HEMS explained to them in terms of how it can save them money. However, participants in the Normative Goal condition had load shifting and the HEMS explained to them in terms of contributing towards UK energy reduction targets. It was intended that the Gain Goal condition would activate participants' goal-frame concerned with gains and losses to their personal resources, whereas it was intended that the Normative Goal condition would activate participants' goal-frame concerned with how they perceive they ought to act in relation to load shifting behaviour and use of the technology. First, how the different goal-frames influenced participants' attitudes and perceptions towards load shifting and using the HEMS was explored. Second, how the goal-frames influenced the factors that predict the participants' perceptions of the usefulness of HEMS and their *Intention to Use* it was explored using predictors from the TAM2, psychological empowerment, environmental citizenship, and environmental concern scales, as derived from Study 1 and applied in Studies 2a and 2b.

6.5.1 Perceptions of the technologies

Participants in both conditions indicated an *Intention to Use* the HEMS and a positive perception of its usefulness and ease of use. Participants also perceived the HEMS usage as being voluntary, as providing good output, having demonstrable results, and being supported by people who influence their behaviour. Participants in both conditions also felt that the technology would not provide any prestige (image) to the user. This supports the findings of Studies 2a and 2b and shows a general positive attitude towards the use of the HEMS.

Considering that smart energy technologies and demand-side management are an increasingly considered strategy by governments, both in the UK and internationally (Wolsink, 2012; Xenias et al., 2015) they remain a relatively new concept for most consumers (Buchanan, Banks, Preston, & Russo, 2016; Raimi & Carrico, 2016; Spence et al., 2015). It is important, therefore to establish the citizens' attitudes towards the new behaviour of load shifting, as well as the new technologies and the implications of the technologies (Hargreaves et al., 2010; Wilson et al., 2015; Wolsink, 2012). Such awareness of the citizen-user attitudes towards these behavioural and technical scenarios will be a crucial beginning to realising the ambition of greater citizen participation in the smart city technology development and governance; a necessity discussed in Chapter 2, and felt to be lacking in the Smart City strategies by the interviewees of Study 1 (Chapter 4). Critically, (as discussed in

Chapters 3 and 5) for smart city and smart energy/grid, strategies to be realised, consumers will need to accept using the technology as the responsibility for responding to electricity supply and depend is shared with them.

6.5.2 Differences in Perceptions of Load Shifting and the HEMS

There were some differences in participants' responses to load shifting and the HEMS between the goal-frame conditions. For instance, in terms of responses to load shifting, participants in the Normative Goal condition had a significantly more positive attitude towards load shifting compared to participants in the Gain Goal condition. However, the conditions had equal levels of intention to load shift, and were equally uncertain about the convenience of load shifting. In terms of responses to the HEMS, the participants in the Gain Goal condition had a significantly higher intention to use the HEMS compared to the participants' in the Normative Goal condition. The participants in the Gain Goal condition also had a significantly higher perception of the HEMS' relevance to their home. There were no significant differences between conditions on the other TAM2 variables.

The differences between conditions might be explained by the construal level theory and psychological distance (Trope & Liberman, 2010). This would be consistent with the discussion of Studies 2a and 2b (Chapter 5). For instance, the normative goal-frame may have primed knowledge and values relating to what one ought to do. The gain goal frame, however may have primed knowledge and values related to maximising one's resources. As such, in the Normative Goal condition, the participants may have felt that engaging in load shifting would be expected of them (i.e. they ought to do it), whilst in the Gain Goal condition, the participants may have evaluated the costs and benefits. As helping to achieve the normative goal of energy reduction through load shifting is a relatively abstract goal (compared to maximising one’s resources), it would considered in value based terms (Eyal et al., 2009). This would lead to load shifting being considered with more positive attitudes, greater evaluation of the pros than the cons, and a focus on desirability rather than feasibility compared to when load shifting was framed with the relatively concrete goal of maximising one’s resources (Trope & Liberman, 2010). As such, participants reported a significantly more positive attitude towards load shifting in the Normative Goal condition than they did in the Gain Goal condition.

Whilst the load shifting behaviour may have been construed at a higher, abstract level, participants may have considered the use of the HEMS at a lower, concrete level construal. This would mean they thought about using the HEMS in concrete, practical terms (Eyal et al., 2009). Therefore, in the Gain Goal condition, when the HEMS was explained in terms of being a technology to help gain/avoid the loss of money, participants may have felt that the HEMS was a tool to help them achieve their goal of maximising their resources (money). Therefore, the participants in the Gain Goal condition had significantly higher *Intentions to Use* the HEMS and perceived it as significantly more relevant to their home compared to participants in the Normative Goal condition where the practicalities of using the HEMS might not have been as compatible with the abstract, normative goal for load shifting.

6.5.3 Differences in Predicting Intention to Use the HEMS when Framed with Different Goals

In terms of predicting the *Intention to Use* the HEMS, a model was generated for each condition. In support of Studies 2a and 2b, the TAM2 predictors did not perform very well as predictors of *Intention to Use* the HEMS. However, as in Studies 2a and 2b, in both the Gain Goal condition and the Normative Goal condition, *Intention to Use* the HEMS was positively predicted by the participants' perceptions of its usefulness, ease of use and its relevance to their home. There were also four differences between the models with *Environmental Citizenship*, *Voluntariness* and *Perceived Control*, and *Goal Internalisation* having different influences between the conditions. These will now be discussed.

6.5.3.1 Environmental Citizenship is only a predictor in the Gain Goal Condition.

Firstly, in the Gain Goal condition, *Environmental Citizenship* had a positive effect on the participants *Intention to Use* the HEMS, mediated through *Perceived Usefulness.* However, this effect was not present in the Normative Goal condition, suggesting that *Environmental Citizenship* was less influential when the technology was framed as being of benefit to UK energy reduction. This is perhaps contrary to expectations given that environmental citizenship is related to pro-environmental behaviours (Dobson, 2007; Stern, Kalof, Dietz, & Guagnano, 1995) and pro-environmental behaviour is often normative (Lindenberg & Steg, 2013). This suggests, therefore, that when normative concerns are *not* primed (i.e. in the Gain Goal condition), it is the individual's willingness to support pro-environmental action (i.e. be an environmental citizen) that predicts intention to use the

HEMS. In contrast, when normative considerations *are* primed the willingness of the individual is less important as they are complying with what they perceive as the normative action. This finding could be related to the finding in Study 2b that *Environmental Concern* predicted *Perceived Usefulness* and therefore, was discussed further in the overall discussion (Chapter 7).

6.5.3.2 Gain Goal-Frame Leads to Consideration of Compliance

The influence of *Environmental Citizenship* in the Gain Goal condition might balance the direct negative influence of *Voluntariness* on *Intention to Use* the HEMS observed in that condition. The participants felt that use of the HEMS would be voluntary. In the Gain Goal condition this perception decreased the individual's intention to use it. This might be because it is their personal money (resource) and so it is up to them whether they try to save it or not. Therefore, in motivational terms, it is whether they find the possibility of saving money enough of an extrinsic reward to overcome the effort of doing something they do not have to do (Gneezy, Meier, & Rey-Biel, 2011). As such, as shown in the Gain Goal condition, their *Intention to Use* the technology needs to be intrinsically motivated by pro-environmental values (i.e. those of *Environmental Citizenship*). In contrast, those in the Normative Goal condition are complying with what they perceive as the normative behaviour, therefore there is less need for personal considerations – using the HEMS is just something one ought to do. Therefore, *Voluntariness,* as with *Environmental Citizenship,* does not significantly influence individuals' *Intention to Use* the HEMS for normative goals, but they do for gain goals.

6.5.3.3 Perceived Control is a Consideration for Normative Goals

In contrast to the personal considerations primed in the Gain Goal condition, the Normative Goal condition may have primed participants to consider other people. This is suggested by the psychological empowerment variable of *Perceived Control* negatively influencing the *Perceived Usefulness* of the HEMS in the Normative Goal condition. This influence was not observed in the Gain Goal condition. The *Perceived Control* factor related to the participants' perceived control over the energy used in their neighbourhood. The Normative Goal, therefore, may have activated considerations of the extent to which the participant perceived themselves as having the power (the ability, control) to influence other people (Menon, 2001). The less power to influence others in their neighbourhood the participant perceived themselves as having, the more they viewed the smart energy technology as being useful. In contrast, as the Gain Goal focused people's attention on the potential for gains and losses in personal resources, consideration of the ability to influence others' energy use will be less relevant and so less influential on perceptions of the HEMS.

Perceived control over the neighbourhood's energy use may have been activated because load shifting, in the Normative Goal condition, was explained as being a behaviour that all households in the neighbourhood would need to engage in to achieve the goal of peak reduction. As such, it was a collective goal, with the implication being that all households would need to co-operate and act fairly in order to achieve the goal. The individual, therefore, would need see themselves as being an influential actor within the collective (which in this case is the neighbourhood). In other studies (e.g. Ajzen & Madden, 1986; Armitage & Conner, 1999), perceived control has been found to predict individuals' behaviour, whilst a perceived lack of control predicts not acting (Rodgers, Conner, & Murray, 2008). Participants of Study 3 indicated that they did not perceive themselves as having control over their neighbourhood’s energy consumption, but they did still have an intention to load shift (to act). As such, participants may have felt that the HEMS offered a way for them to gain more control and influence over their neighbourhood’s energy consumption, and so greater control over their intention to pursue the normative goal of load shifting (K. Clark & Sefton, 2001).

An alternative explanation of the negative influence of *Perceived Control* on *Intention to Use* is that participants may have felt that the HEMS would mean they could defer responsibility for regulation of their neighbourhood’s energy consumption to the technology. Certainly, automated technology can reduce the feeling of responsibility to act (Murtagh et al., 2015) and in one study, the perceived difficulty in adapting energy consumption routines was found to lead participants to view smart appliances as necessary (Paetz et al., 2012). This reflects the discussion of the interviewees in Study 1 where a tension was identified between using smart technologies to increase citizens’ ability to participate in the city management, whilst also using technology to potentially remove control by automating procedures. To extend this reasoning, it would be interesting to measure if using a HEMS gives people a greater sense of control (empowers them) or whether it simply reduces their desire/need for control.

6.5.3.4 A Gain Goal-frame weakens the Influence of Collective Goals

The argument that the Normative Goal condition primed participants to consider their use of the HEMS in terms of achieving the wider goals of the technology was further demonstrated by the psychological empowerment factor of *Goal Internalisation* negatively moderating the influence of *Home Relevance* on *Intention to Use* the HEMS in the Normative Goal condition. This is because the negative moderation was not found in the Gain Goal condition, despite participants' reported levels *Goal Internalisation* being the same between the conditions.

The lack of moderation in the Gain Goal condition goes in line with the goal-framing theory literature that suggests self-interested goals, such as those related to personal gain, are *a priori* stronger (i.e. more cognitively accessible) than normative goals (Lindenberg & Steg, 2013). Therefore, it might be expected that the typically stronger, personal and pragmatic considerations of *Home Relevance* would not be influenced by the typically weaker normative concerns of the UK energy reduction targets (*Goal Internalisation*). Accordingly, this is what was observed in the Gain Goal condition, with *Home Relevance* having a strong, direct influence on *Intention to Use*. However, in the Normative Goal condition, an internalised, normative goal was able to negatively moderate the direct influence of *Home Relevance* on *Intention to Use.* This apparent undermining of a potentially stronger, self-interested goal by a typically weaker, normative goal, is therefore interesting and will be discussed further.

Lindenberg and Steg (2013) argue that in order for a normative goal-frame to be able to compete with a gain goal-frame there needs to be support from social cues or feedback that indicate what the norm is, that the norm is being adhered to by others and that the normative goal is important to pursue (Keizer et al., 2011). Implying what "ought to be done" in the Normative Goal condition (i.e. "It would be beneficial for the UK if you…") may have provided the participant with a normative cue that load shifting is an important normative goal to which individuals ought to contribute in order to benefit the collective. As such, knowledge structures and attitudes related to the issues of needing to reduce energy consumption and contribute towards the UK's targets may have been activated and a normative goal-frame was able to become more dominant (Lindenberg, 2001; Lindenberg & Steg, 2007). Because of the dominant normative goal-frame, the internalised, normative goal of UK energy reduction would be more salient for those in the Normative Goal condition compared to those in the Gain Goal condition. This greater salience of the UK energy reduction goal may then have been expressed by the *Goal Internalisation* factor negatively moderating *Home Relevance* in the Normative Goal condition, but not in the Gain Goal condition.

Whilst the normative goal-frame of the Normative Goal condition primed and supported the internalised energy reduction goal, it is arguable that the gain goal-frame (triggered by the Gain Goal condition) would not only *not* support the internalised goal, but it would actually weaken a potential normative goal-frame by priming and supporting the considerations of *Home Relevance* (Keizer, Lindenberg, & Steg, 2008). Considering the implications of load shifting in terms of how it would impact on their personal resources would perhaps prime pragmatic considerations of how the technology would fit into their homes and lifestyles (as opposed to what would best support the collective efforts of the UK, as in the normative goal-frame). Therefore, despite participants in the Gain Goal condition indicating equal levels of *Goal Internalisation* to those in the Normative Goal condition, considerations of *Home Relevance* was able to remain a direct influence on *Intention to Use* without negative moderation from the internalised UK energy reduction goals.

6.5.4 Limitations and Future Directions

The title used to advertise the survey and the use of the Prolific Academic participant pool raises an issue of generalizability. It is a common challenge within participant recruitment that those who respond may be more motivated and/or interested in the research topic than those in the population who did not respond. This issue has been raised within studies of energy management technologies, with those who are very interested in their energy consumption being more likely to take part (Van Dam et al., 2012). With the present research, the title of the survey, “When shouldn’t we use electricity?”, may have been more attractive to individuals who were already interested in issues relating to electricity consumption. As a result, the sample obtained in the study may have been skewed to represent those who have higher levels of interest in electricity consumption than might be found in the wider population. To some extent, use of the participant pool may have meant that the survey reached a sample who were not necessarily interested in electricity management *per se*, but rather in just taking part in the questionnaire in return for the payment. However, given that the participant pool is, of itself, a subpopulation, it will still be necessary for future electricity management and technology acceptance studies to increase the diversity of the population sample. In particular, it would be interesting to seek individuals have limited interest in energy management and express no intention to load shift or use a HEMS. Potentially, these participants could be reached by using a blind recruitment process wherein the title invites participants to complete a survey with a broad topic that is less indicative of the focus of the survey, thus broadening the appeal of the survey to beyond those with a specific interest in electricity management.

Whilst it is unlikely the participants would have had any experience of the HEMS or load shifting, it would have been interesting to ascertain the participants’ previous experience with other energy monitoring technologies, or time-of-use tariffs. Frequently, individuals who sign up to trials of energy management technologies, such as the HEMS, have had prior experience of energy management and now wish to try something new (Hargreaves et al., 2010; Van Dam et al., 2010; Woodruff et al., 2008). In the TAM2 (Venkatesh & Davis, 2000), experience was shown to reduce the importance of subjective norms on intention to use the technology. This suggests that individuals’ own experience gains more importance than perceptions of norms through use. Whilst in Study 3 subjective norm did not have a significant effect on intention to use, it could have been important to consider experience as a predictor and/or moderator of the HEMS' perceived usefulness and the intentions to use it.

In the present study, no information was given to participants about other people's levels of engaging in the normative behaviour (load shifting), it was dependent on the participant feeling that others should engage in load shifting (i.e. that it is normative; Lindenberg & Steg, 2013). Considering that the normative goals are so vulnerable to gain and hedonistic goals, it might be of value for future studies to strengthen the normative goals further by including information about other individuals' levels of acceptance or perhaps other people's motivations for intending to use the HEMS. For instance, Keizer et al. (2011) found that when there was an anti-littering message, and there was litter already visibly present in the area, people's subsequent littering was greater than when there was no anti-littering message (but still visible litter). This suggests that when a normative goal is activated (no littering), seeing the norm being broken (littering) means the individual is more likely to then break the norm themselves. As such, it would be interesting to manipulate or measure the participants' perceptions of whether they think others will engage in load shifting and accept the HEMS to see the influence on the participants' intentions. It might be expected that if load shifting is framed as a normative goal, but participants feel others would not engage in it, it will lead to a reduced intention to load shift or use the HEMS.

Similar to the lack of information about the social norms in the Normative Goal condition, the Gain Goal condition did not give any indication as to the amount of money that could be saved by load shifting. Goals relating to gain are related to maximising resources (Lindenberg & Steg, 2007). Therefore, the expectations about the amount to be gained from engaging in load shifting will be important. This might be indicated in the present study by the finding that the intention to load shift was lower in the Gain Goal condition, but the intention to use the HEMS was higher. The load shifting behaviour may have seemed too effortful until a technology was introduced that could reduce the amount of effort, thereby still increasing the individuals' monetary gains, but with less effort. Focus group have indicated that cost savings would need to be high in order for individuals to be willing to endure the perceived effort of load shifting (Goulden et al., 2014). Participants may have inferred a high level of cost savings, leading them to have a higher intention to use the HEMS than would have been present if the cost savings were suggested to be low.

6.5.5 Implications

As discussed in Chapter 3, the main feature that is often used to entice consumers into using energy management devices or reduce their energy consumption is the potential to help the consumer to save money on their energy bills (Giordano & Fulli, 2012). The present study has shown that using a monetary incentive may cause householders to think pragmatically about the value than an individual technology option (e.g. the HEMS) brings to their home. As the monetary savings from load shifting may not be very large, per household (M. Davis, 2011) and householders tend to prioritise comfort, convenience and wellbeing above load shifting (e.g. Paetz et al., 2012), householders may not perceive using the HEMS to load shift as being relevant to their home, therefore, their intention to use the HEMS may be reduced. As shown in the present study, however, using a normative based campaign may lead to householders to respond more to the overarching rationale for the technology and to load shifting, as opposed to the specifics of the technology. Therefore, other motivations, such environmental values, or social norms will be important to target within smart energy technology and load shifting campaigns (Stern, 2000).

6.6 CONCLUSIONS

Taken as a whole, the findings from Study 3 suggest that the goal-frame does influence the perceptions of the HEMS and the predictors of its usage. On the one hand, the gain goal-frame led to *Environmental Citizenship* and *Home Relevance* influencing intentions to use, with perceptions of *Voluntariness* negatively influencing intentions. On the other hand, the normative goal-frame lead to *Home Relevance* also positively influencing *Intention to Use* the HEMS, but then *Perceived Control* over neighbours' energy consumption negatively influenced *Perceived Usefulness* of the HEMS, and the internalised UK energy reduction goal (*Goal Internalisation*) negatively moderated the influence of *Home Relevance* on *Intention to Use*. These differences could be explained by the fact that an intention to engage in the normative goal of load shifting requires compliance to the perceived norm and so neither *Environmental Citizenship* nor perceived *Voluntariness* are activated or influential in forming *Intention to Use*, unlike with a gain goal-frame. Conversely, an intention to engage in a gain goal is more individualistic and pragmatic, and so does not need perceived control over others' energy consumption, or internalised UK energy reduction goals to form *Intention to Use*, unlike with a normative goal-frame. Ultimately, the gain goal-frame lead to a slightly higher *Intention to Use* the HEMS to achieve monetary savings, but the normative condition had a higher positive attitude towards load shifting itself. In the following chapter, these findings are discussed further and in conjunction with the findings of Study and Studies 2a and 2b.

Chapter 7: Overall Discussion

7.1 Thesis Overview and Key Findings

The aim of this thesis was to explore the smart citizen concept from a psychological perspective. This is because the sustainability challenges that are threatening cities are increasingly being tackled through the use of smart technologies. These smart technologies have implications for the citizen, such as intending for the citizen to participate in the strategies or change behaviour. Despite these implications, the current discussions of smart citizens within the extant literature were found to be abstract and limited in their considerations. Through the use of elite-interviews, informed questionnaires, and mediation and moderation analysis, potential influential factors on citizen acceptance of smart technologies were identified, operationalised, and statistically modelled. An overview of the studies and key findings are given below, followed by a discussion of the overall findings.

The literature review (Chapters 2 and 3) identified the nature of the smart city and smart citizens, and how research might further develop understanding of what it will mean to be a smart citizen in terms of using technology and responding to smart technology agendas. In Study 1 (Chapter 4) the future of cities and smart citizens were explored through interviews with UK city stakeholders who were involved in smart city initiatives. Overall, the stakeholders saw the opportunity for technologies to empower citizens, but were also aware of the danger of disempowering citizens through top-down technocracies and an automation of service removing responsibility over the goals of the smart city and/or aspects of the citizens lives (such as when they use electricity, when they travel etc.). The interviewees felt that citizens need to be adopt the goals of the smart city in order to create shared responsibility for the development and sustainability of the city. From these interviews, four themes were defined 1.) “Citizen Exclusion and Inclusion”, 2) “Smart Technology and Citizens”, 3) “Collective Responsibility”, and 4) “Individual Differences”. Brief summaries of the themes are given in Table 37.

Table 37. Definitions of themes developed from interviews in Study 1

1.	“Citizen Exclusion and Inclusion”	The potential for citizens to be disempowered by the currently top down nature of smart city discussions and strategies. Citizens need to be more aware of developments in the city to the extent that they become demanding citizens.
2.	“Smart Technology and Citizens”	The interaction between smart technologies and the citizen. Highlighted a tension between smart technologies which disrupt behaviour in order to promote sustainable behaviours, and technologies that automate the behaviour in order to create optimal sustainability.
3.	“Collective Responsibility”	The need for citizens to have greater responsibility for achieving the goals of the city and a greater willingness to act for the benefit of the collective as opposed to that of the individual.
4.	“Individual Differences”	The challenge of individuals having different desires and motivations for accepting or not accepting the smart technologies and engaging with the smart city agendas. These individual differences needed to be understood in order to promote the acceptance of smart city technologies

The themes from Study 1 were discussed in relation to psychological empowerment (Menon, 1999), environmental citizenship (Stern, 2000), and environmental concern (Dunlap et al., 2000). These concepts enabled the operationalisation of the characteristics identified as important to the development of smart citizens by the interviewees of Study 1 and the literature review. Studies 2a, 2b, and 3 then focused on quantitatively testing the importance of psychological empowerment, environmental concern, and environmental citizenship for smart technology acceptance. Home energy management systems (HEMS) were the chosen target smart technology used within these studies. The HEMS provided an appropriate technology in which to explore the importance of these factors within smart city strategies. This is because the HEMS represent a key aspect of smart city strategies (Morvaj et al., 2011) and their success is interrelated with their acceptance and utilisation by the citizen (Goulden et al., 2014).

As the HEMS are relatively new technologies, an approach, which drew on the methods of an Information and Choice Questionnaire (ICQ; de Best-Waldhober et al., 2009), was used. This involved informing participants about the HEMS and the context driving the need for the HEMS. Their choices were recorded in terms of responses to the items from the Technology Acceptance Model 2 (TAM2; Venkatesh & Davis, 2000) regarding use of the HEMS. These included participants' perceptions of the usefulness, ease of use, and home relevance of the HEMS. In addition, psychological empowerment, environmental citizenship, and environmental concern were measured. These responses were then used to statistically predict participants' *Intention to Use* the HEMS using regression based mediation and moderation analysis. The information provided in the questionnaires was different in Studies 2a, 2b, and 3 in order to explore the effect of different framings of the HEMS.

In Study 2a (Chapter 5), the need for the HEMS was framed in terms of reducing household energy consumption in order to reach UK energy reduction targets and mitigate climate change. In Study 2b, the need for the HEMS was framed in terms of load shifting household energy consumption in order to save the householder money and to help match electricity supply with demand. In both studies it was found that *Perceived Usefulness* mediated a positive effect of *Perceived Ease of Use* and *Home Relevance* on *Intention to Use.* It was also found that, in both studies the psychological empowerment factor of *Goal*

Internalisation negatively moderated a direct influence of *Home Relevance* on *Intention to Use* the HEMS. Then, in Study 2b only, *Perceived Usefulness* also mediated a positive effect of *Environmental Concern* (measured using the New Ecological Paradigm [NEP] scale) on *Intention to Use* the HEMS. The final models from Study 2a and Study 2b are presented in Figure 14 below.

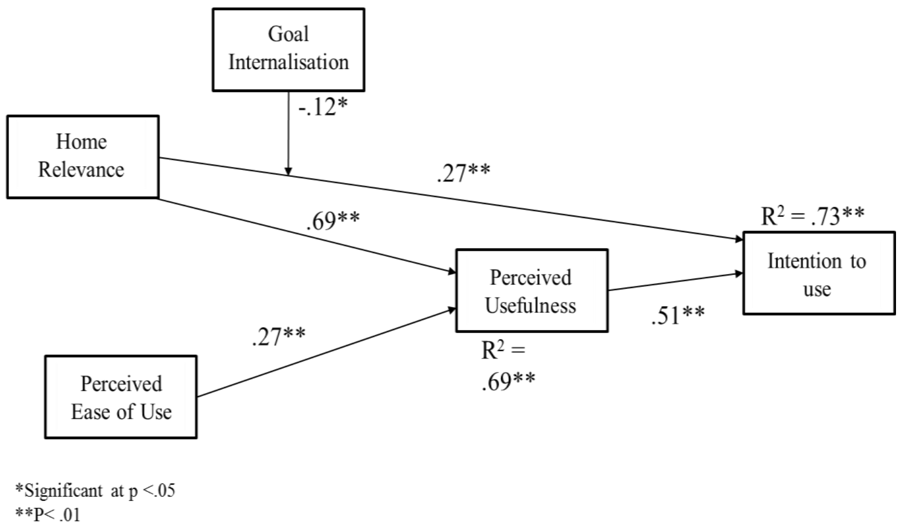
The different contextual framings were used in Study 2a and Study 2b to explore *Intention to Use* the HEMS when it was explained in terms of its two potential functions for energy management. It was recognised during the discussion of Studies 2a and 2b, however, that there had been another potential framing effect, which might have influenced participants' perceptions of the HEMS. As outlined above, Study 2a used an energy reduction frame (i.e. "help the UK to reach its targets for 2030"), whilst Study 2b used a load shifting frame (i.e. "how could real time pricing help you to save money"). Thus, as well as investigating the effects of two different behaviours (i.e. energy reduction and load shifting) Studies 2a and 2b were also investigating the impacts of two different incentives for action (i.e. environmental benefits and financial saving, respectively). As Studies 2a and 2b were not designed with the intention to enable direct, statistical comparisons of the different framing on perceptions of the HEMS, it was not possible to distinguish the potential influence of the behaviour from the potential influence of the incentive.

Evidence has shown that framing behaviours as either pro-environmental or as for financial savings have different influences on behaviour (Kranz & Picot, 2012; Steinhorst et al., 2015). For instance, a behaviour (having car tyres changed) was engaged in less when framed as being about saving money as compared with when it was framed about being environmentally beneficial (Bolderdijk et al., 2013). With this in mind, it was considered that the influence of the incentive that was given for using the HEMS should be explored further within a final study. As such, Study 3 aimed to more formally compare the influence of an ‘environmental’ frame (i.e. ‘helping to reach energy reduction targets’) versus an ‘economic’ frame (i.e. ‘financial savings’) on individuals’ perceptions of and intention to use the HEMS.

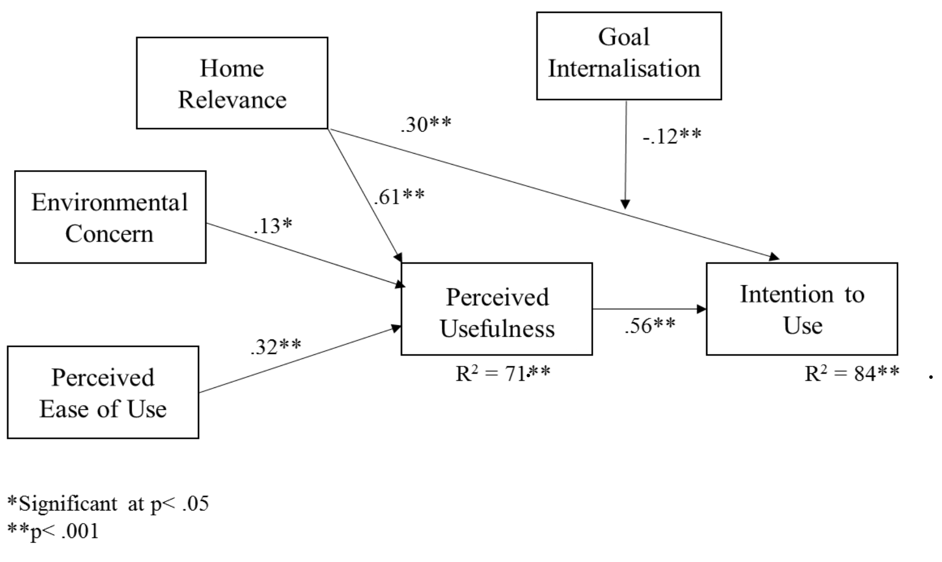
In Study 3 (Chapter 6)—based on goal-framing theory (Lindenberg & Steg, 2007, 2013) and the finding that goal-frames can be triggered by semantic priming (Liberman et al., 2004)—it was hypothesised that the ‘environmental’ frame should activate a normative goal-frame (i.e. what one ought to do) as the HEMS was related to load shifting to benefit the UK. In contrast, the ‘economic’ frame was hypothesised to activate a gain goal-frame (i.e. how one can maximise one’s resources) as using the HEMS was related to load shifting for personal benefit (i.e. saving money). The effects of these two different goal-frames on acceptance of and perceptions of the HEMS were then modelled. The final models of each condition are shown in Figure 15 below.

The final models of Study 3 showed that in both goal-frames (normative and gain), *Perceived Usefulness* mediated a positive influence of *Perceived Ease of Use* and *Home* Relevance on *Intention to Use* the HEMS. There were differences, however. When the HEMS was framed with a gain goal, *Perceived Usefulness* also mediated a positive influence of *Environmental Citizenship,* and *Voluntariness* had a negative, direct influence on *Intention to Use* the HEMS. These did not have an influence when the HEMS was framed with a normative goal. Instead, when the HEMS was framed with a normative goal, *Perceived Control* had a negative influence on *Perceived Usefulness,* and *Goal Internalisation* negatively moderated the direct influence of *Home Relevance* on *Intention to Use* the HEMS.

The outcomes of studies 2a, 2b, and 3 will be now discussed in relation to each other to consider the implications for acceptance of smart energy technologies, such as the HEMS (and by extension, load shifting behaviours) and how the exploratory research of this thesis has contributed to the understanding of smart citizens.

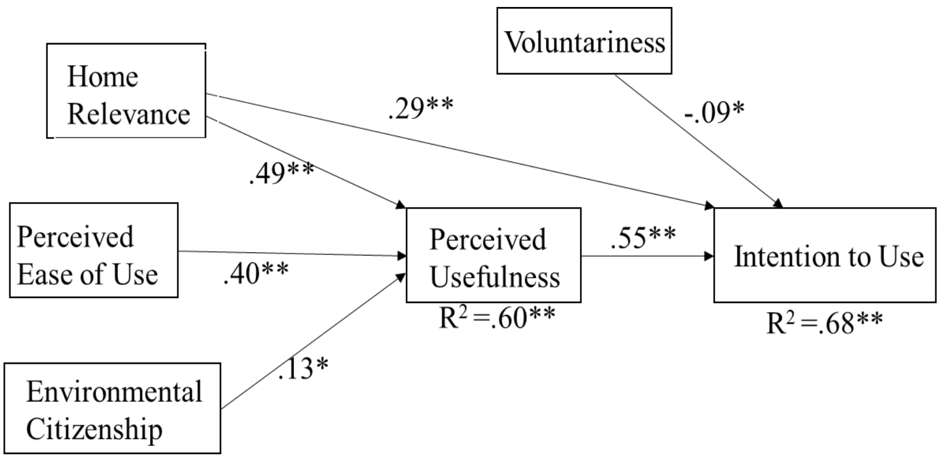


Conceptual model for predicting Intention to Use the HEMS with Goal Internalisation moderator in Study 2a (Energy Reduction).



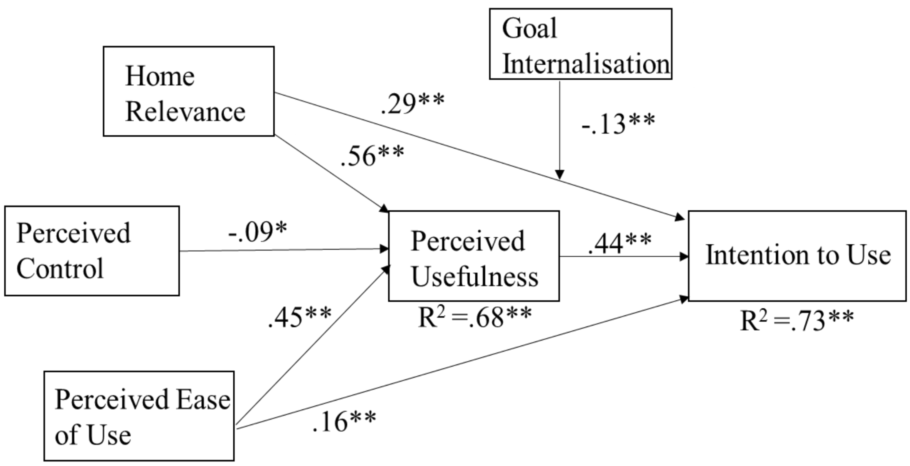
Conceptual model for predicting Intention to Use the HEMS in the Load Shifting condition with moderator in Study 2b (Load Shifting).

Figure 14: The final models from Study 2a (top) and Study 2b (bottom).



*Significant at p <.05
**p < .01

Model for predicting Intention to Use the HEMS in the Gain Goal condition.



*Significant at p <.05
**P< .01

Moderated model for predicting Intention to Use the HEMS in the Normative Goal condition.

Figure 15: The final model from each goal-framing condition of Study 3.

7.1.1 Reliable predictors of Intention to Use the HEMS

Whilst there were some differences in the significant predictors in each model, across the studies, there was also a high level of consistency in the perceptions of the HEMS and the predictors for *Intention to Use* the HEMS. The findings of this research illustrate that (a) how relevant people perceive a HEMS to be for their home (i.e. *Home Relevance*), (b) how useful they perceive a HEMS to be for them (i.e. *Perceived Usefulness*), and (c) how easy they feel a HEMS will be to use (i.e. *Perceptions of Ease of Use*), reliably influence the participants' intention to use the HEMS. These were significant predictors across all three studies in this thesis (i.e. four, independent population samples). This significance was irrespective of the framing used when presenting information to the participants in each of the studies. Furthermore, across the models of the three studies, *Perceived Usefulness* mediated the effect of the other significant predictors of *Intention to Use*. The only exceptions to this were in the Gain Goal condition of Study 3 where *Voluntariness* directly (negatively) predicted *Intention to* Use the HEMS, and in Studies 2a, 2b, and 3 where it only partially mediated the effect of *Home Relevance* on *Intention to Use*. The implications of these findings are discussed below.

7.1.1.1 Perceived Usefulness and Ease of Use reliably predict of intention to use the HEMS

In the current studies, the *Perceived Usefulness* factor was intended to measure the extent to which a person believed that using the HEMS would enhance his or her energy reduction/money saving experience (depending on the information framing). This consistently had a strong influence on *Intention to Use* (β between .44 and .56) and mediated the other significant predictors in each study (except, as noted, *Voluntariness* in the Gain

Goal of Study 3). These findings corroborate the literature on the TAM (F. D. Davis, 1989) and the TAM2 (W. R. King & He, 2006; Legris, Ingham, & Collerette, 2003; Shumaila et al., 2007). Therefore, the *Perceived Usefulness* of the HEMS, is identified as a robust and important predictor of individuals' Intention to Use the HEMS and mediator of the influence of other factors.

The consistency of *Perceived Ease of Use* as a predictor of perceived usefulness (and indirectly, intention to use) within the current studies is consistent with findings from the extant literature (Shumaila et al., 2007). Therefore, the findings of this thesis support the importance of users perceiving use of energy management systems (like HEMS) as "free of effort" (p. 187) in order to encourage usage (Venkatesh & Davis, 2000). Therefore, *Perceived Ease of Use* is evidently an important factor for technology acceptance. What is challenging about *Perceived Ease of Use,* however, is that the perceptions will partially be due to individual differences and individual experiences with technologies (Agarwal & Prasad, 1999; Burton-Jones & Hubona, 2005). Venkatesh (2000), for instance, investigated antecedents to perceived ease of use and found that greater computer self-efficacy and intrinsic motivation, and less computer anxiety predicted individuals' perception of the ease of use of ICTs. More broadly, these individual differences in the perceived ease of use of smart technologies relates to the concerns of a growing "digital divide" in society (Epstein, Nisbet, & Gillespie, 2011).

The digital divide concept points to the danger that as smart technologies and their benefits advance, those who are not able, do not perceive themselves as able, or are not willing to use the technology, subsequently become disadvantaged in the services and opportunities they can access in cities and society (Gilbert, 2010). Therefore, the findings of this thesis serve to reiterate, particularly in the smart city context, the importance of striving for maximum acceptance and maximum accessibility when designing, distributing, and marketing smart (digital) technologies (Sanders & Stappers, 2008) to prevent the development of a digital divide and subsequent potential for inequalities (James, 2011; Stiakakis, Kariotellis, & Vlachopoulou, 2009).

7.1.1.2 The impact of the 'Home relevance' variable needs further explanation

The *Home Relevance* factor of this study was operationalised as "Respondents' perception of the degree to which the HEMS is applicable to their home. It will be a function of the importance of energy management within their home" (see Table 8, Chapter 5). *Home Relevance* may therefore involve a (conscious or unconscious) calculation of the costs (resources and/or effort) of using a technology (like a HEMS), as well as wider intentions to manage energy use in their household. However, given the reliability of *Home Relevance* as a predictor of *Perceived Usefulness* and *Intention to Use* found in this thesis, future research should explore the factors underpinning perceptions of *Home Relevance.* There could, for instance, be a social element to the relevance of the HEMS. A household may contain multiple occupants who need to agree on how energy is managed and the importance of managing it, for example, which would mean the relevance of the HEMS may have to be socially negotiated (Hargreaves et al., 2013). There could also be concerns with how using the HEMS would disrupt daily household routines (e.g. when showers can be taken or when meals can be made) with families feeling less able to change their routines in response to price signals than those who live on their own (Goulden et al., 2014).

7.1.1.3 Implications of Perceived Usefulness, Ease of Use and Home Relevance for Smart Technology Design

Digital technologies for the home, such as smart thermostats, are increasingly being considered from a user-centric perspective to ensure that controls and displays are as accessible as possible (e.g. Böhm & Szwec, 2013). And approaches such as participatory design (Sanders & Stappers, 2008) and living labs are increasingly being used for the development of smart technologies for the home to aim for maximum adoption of the new technologies (Jahn, Patti, & Acquaviva, 2013). As discussed above, these approaches will be important for ensuring the *Perceived Ease of Use* of smart technologies and removing physical or psychological barriers to citizens being able to use and benefit from smart technologies. Equally, they may offer an opportunity to explore *Home Relevance* further as further understanding the perceptions of *Home Relevance* will help developers to design the household smart technologies that are more relevant to householders, which should lead to greater perception of their usefulness and increase intentions to use them.

7.1.2 Different predictors with different framing

Whilst *Perceived Usefulness*, *Perceived Ease of Use*, and *Home Relevance* were significant predictors in all the models—irrespective of the framing of the information—the other factors found to predict intention to use the HEMS were more dependent on the nature of the information provided to participants within each study (i.e. the framing used). In this thesis, the factors were *Psychological Empowerment, Environmental Citizenship, and Environmental Concern*.

7.1.2.1 Monetary motivations need pro-environmental beliefs

Environmental Concern (measured through the NEP) and *Environmental Citizenship*[6] were retained as predictors in the two models that framed the HEMS in an 'economic' way (i.e. Study 2b and the Gain Goal condition of Study 3). This finding contradicts what might have been expected. For instance, as discussed in Chapter 6, it was hypothesised that *Environmental Concern* and *Environmental Citizenship* would predict the *Intention to Use* the HEMS, but only when the technology was framed in terms of its consistency with environmentally beneficial behaviours. This is because: (a) the NEP has been found to predict pro-environmental behaviours (Steg & Vlek, 2009); and (b) past environmental behaviours (conducive with environmental citizenship) have been found to predict future environmental behaviours (Knussen et al., 2004).

Whilst unexpected, the significance of *Environmental Concern* and *Environmental Citizenship* in the monetary framing conditions could perhaps be explained by the participants needing to off-set their egoistic intentions. For instance, Bolderdijk et al. (2013) found that individuals engaged in changing their car tyres less in response to messages of financial gain (compared to messages of environmental benefits) for fear of being seen as "greedy" (p. 414). Equally, Camerer (2010) found that even within a gain goal-frame, peoples' actions were still influenced (to some extent) by normative concerns. As such, in the present studies, a subordinate normative goal may still have had some influence on the participants' dominant gain goal-frame, thus making them aware of what they ought to do (e.g. help the environment and/or not be 'greedy'), even though they intended to pursue a

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[6] These constructs are actually theoretically related. In the Value-Belief-Norm model of environmental behaviour, the NEP is argued to be a belief which subsequently predicts environmental citizenship (Stern, 2000; Stern et al., 1999).

gain goal (Lindenberg & Steg, 2007). Therefore, it could be argued that whilst framing the HEMS in terms of economic gain might have primed participants to think of the personal benefits of the technology, to the extent that the HEMS was perceived as having environmental benefits, participants might have also considered their pro-ecological beliefs in order to self-justify the opportunities for personal gain (e.g. 'Yes, I'm doing this for the monetary savings but also because I care about the planet, so I'm not being too greedy'). This would be akin to needing to reduce cognitive-dissonance between having a positive self-concept (i.e. not being greedy), but then acting in a way which could be perceived as greedy (Bolderdijk et al., 2013; Thøgersen, 2004).

In contrast to using the HEMS for a gain goal, intending to use the HEMS for a normative goal (as in Study 2a and the Normative Goal condition of Study 3), may not have been perceived as egoistical as using it was for the collective benefit. Therefore, intending to use the HEMS might not have required off-setting or self-justification (i.e. no dissonance to resolve). As such, environmental concern and environmental citizenship were not activated in Study 2a and the Normative Goal condition of Study 3. In essence then, framing the HEMS in terms of monetary benefit could strengthen the links between a persons' environmental beliefs and their *Intention to Use* a HEMS as people seek to justify their personal gain from using the technology by considering the environmental benefits of using the technology. This finding could be investigated further by requesting individuals' justifications for using the HEMS after they have indicated their intention to use it either in an interview or in the survey. It would be expected that in the gain goal condition, saving money would emerge as the main reason, but this might be caveated with wanting to reduce energy consumption. Reasons in the normative goal condition, however, may focus on feeling the need to contribute towards the goal.

As discussed in Study 3 (Chapter 6), the significance of the pro-environmental factors in the economically framed models is particularly pertinent to the Gain Goal condition of Study 3. This is because, in this condition *Voluntariness* was seen to negatively influence intention to use the HEMS (i.e. the more volitional adoption of the technology appeared to be, the less likely people were to intend to use it). However, the negative impact of this factor was offset by the positive influence of *Environmental Citizenship*. This is an important finding considering that the adoption of many smart energy technologies (e.g. smart meters) in the UK is currently voluntary. Furthermore, the smart energy technologies are typically marketed in terms of helping users to save money (i.e. a gain goal-frame). These findings, therefore, have implication for the smart energy technology campaigns.

Currently smart energy technologies are predominantly framed in terms of economic benefit (e.g. they will help you save money through more accurate billing). Studies have, however, shown that realised monetary savings can be small at the individual level (Larsen & Sønderberg Petersen, 2009; Strengers, 2010) and that individuals do not trust the claims made by retailers about the money they will save money from installing and using smart energy technologies (Spence et al., 2015). Therefore, this is a situation where an optional (voluntary) technology with nominal financial benefits is being promoted to consumers; a situation that is likely to negatively impact upon people's *Intention to Use* the technology. From the current set of studies, it would appear that beliefs relating to environmental concern can be a means of offsetting the negative influence of the voluntariness of the technology. However, the individual would need to possess strong enough environmental beliefs for them to influence their intentions. In contrast, if the adoption of smart energy technologies were to remain voluntary, but the developers and campaigns used a normative goal-frame (as tested in Study 3 e.g. you need to help reduce peak demands), then the voluntariness of the behaviour may not be a significant factor in predicting *Intention to Use* and so would not need to be offset by beliefs relating to environmental concern. This would be an advantage for the smart energy technology acceptance if the individuals do not possess strong enough pro-environmental beliefs to motivate them to use the voluntary energy management technologies.

7.1.2.2 Goal internalisation reduces influence of pragmatic considerations

The effect of *Goal Internalisation* was also found to be different with the different information framing conditions. *Goal Internalisation* is a factor of psychological empowerment (Menon, 1999, 2001) and was used during Studies 2a, 2b, and 3 to refer to the internalisation of national level objectives for energy reduction. This was done in order to better understand how a citizen's adoption of national energy goals and targets would influence their acceptance of the HEMS. A goal is argued to become internalised when the individual shares the values of the collective to which the goal is relevant. Once internalised, people should be motivated to strive towards achieving the collective, shared goal (Deci & Ryan, 2000; Leonard et al., 1999). It was found that *Goal Internalisation* negatively influenced the direct effect of *Home Relevance* on *Intention to Use* the HEMS across Studies 2a, 2b and the Normative Goal condition of Study 3.

In the discussion of Studies 2a and 2b, Construal Level Theory (CLT) and psychological distance were suggested as explanations for the negative moderation between *Home Relevance* and *Intention to Use* (Trope & Liberman, 2010). However, the lack of negative moderation in the Gain Goal condition of Study 3 meant a further explanation of the effect was needed. As such, it was argued that, in contrast to the Gain Goal condition, the normative goal-frame activated in the Normative Goal condition may have primed values, beliefs and knowledge structures related to what one ought to do (Lindenberg & Steg, 2013). This priming would have made the goal of UK energy reduction more salient to the participant (vs. the Gain Goal condition) as the UK energy reduction goal also represents a collective goal. Therefore, the internalised goal of UK energy reduction in the Normative Goal condition would be salient enough to moderate the direct influence of *Home Relevance* on *Intention to Use* the HEMS. Conversely, the gain goal-frame in the Gain Goal condition would not have primed values, beliefs, and knowledge structures related to what one ought to do. Therefore, the goal of UK energy reduction would not have been as salient to the participant and so did not become salient enough to moderate the direct influence of *Home Relevance* on *Intention to Use* the HEMS.

The findings of Studies 2a, 2b, and 3, offer evidence that an internalised, collective goal may undermine (i.e. negatively moderate) more individualistic considerations when forming intentions to use a smart energy technology. However, the internalised, collective goal will not undermine individualistic considerations if the behaviour has an explicit economic frame. As such, it is reasoned, that a strategy or campaign for smart energy technologies which focuses on the internalisation of shared goals may be an effective way of reducing the influence of individualistic concerns on behaviours (such as using a HEMS or load shifting) where the collective goal needs to be prioritised over individuals' own goals. This finding is in line with the GFT based argument wherein a dominant normative goal-frame will suppress a gain or hedonistic goal-frame (Lindenberg & Steg, 2007, 2013) and echoes the argument that an individual who is motivated by an internalised goal will be less concerned with extrinsic rewards (Leonard et al., 1999). More broadly, it is also consistent with the 3rd Study finding that *Voluntariness* did not negatively influence *Intention to Use* the HEMS in the normative goal-frame, but it did in the gain-goal frame. This suggests, therefore, just as concern for the *Home Relevance* of the technology can be reduced in a normative goal-frame, so too can concerns for whether using it is voluntary or not.

7.1.2.3 Implications for Using Normative Goals

Whilst a normative goal-frame may have advantages for technology acceptance bypassing individuals' considerations of whether the technology is voluntary and reducing concerns of whether the technology is relevant to their home; evidence shows that activating and maintaining a normative goal-frame is difficult (Lindenberg & Steg, 2013). This is because normative goals are often *a priori* weaker than more self-interested goals, such as gain goals or hedonic goals. As such, the normative goals are more easily displaced (Lindenberg & Steg, 2013). For instance, concerns for gain tend to displace concerns for norms as the cost of the normative behaviour increases (Bamberg & Schmidt, 2003; Diekmann & Preisendörfer, 2003; Gatersleben et al., 2002). Furthermore, a small number of people deviating from a social norm can undermine the feeling in others that the norm needs to be adhered to (Cialdini et al., 1990). Therefore, in order to be maintained, normative goals need support from external social cues and supporting feedback from others to promote the importance of the normative goal compared to hedonistic or gain goals (Keizer et al., 2011). Alternatively or additionally, if hedonistic and/or gain goals are compatible with a dominant normative goal-frame, then they will strengthen the pursuit of the normative goals (Lindenberg & Steg, 2007). Therefore, normative goals could be aligned with the hedonistic and/or gain goals in order to prevent their displacement.

To promote and support normative goals, Lindenberg and Steg (2013) suggest the use of public campaigns to moralize (normalise) certain behaviours or evaluations and to "boost" the appropriate social values. Supporting normative goals in the smart city context could come from (at least) two potential sources. The first is the city leaders, local authorities, and influential stakeholders inspiring the internalisation of shared goals for the city through transformational leadership which can promote the internalisation of collective goals (Sharma

& Kirkman, 2015). A citizen who is only motivated to behave in line with a city's goals through compliance with external regulation or for personal gains, is arguably one who is disempowered; they may not share the goal and only pursue it due to external forces (Lavergne, Sharp, Pelletier, & Holtby, 2010). Conversely, those who share the goal will be motivated to pursue it as the goal is important to them and their values, therefore, the goal pursuit will be intrinsically rewarding (Deci & Ryan, 2000; Leonard et al., 1999). The desire for citizens to share the goals of the city was discussed by the interviewees of Study 1, who felt that there needed to be a greater communication of the goals for the city to the citizens in order to generate shared targets. Indeed, in civics literature, a fundamental aspect of a participatory citizen is one who has a "communal vision" (Cohen & Schuchter, 2013; p.190). Therefore, city leaders need to promote and share the goals of the smart city in order to promote the internalisation of shared goals for the city by the citizens (Sharma & Kirkman, 2015).

A second way in which normative goals could be promoted and supported is through the smart technologies themselves. Technologies have the potential to enable or constrain our actions, our perceptions, and our expectations of ourselves and others (Nahuis & Van Lente, 2008). As such, literature on values and design are concerned with how values are materialised in the design process, and how they affect the adoption and use of the technology and subsequently impact on society (Le Dantec, Poole, & Wyche, 2009; Shilton, 2010). Currently, smart technologies are typically developed to cater for individuals' personal financial gains and comfort (Evans et al., 2013). A smart technology, such as the HIVE (a home heating management device), for instance, is currently designed and marketed as being for the user's comfort and financial savings (see: www.hivehome.com). The research of this thesis suggests that such an approach will promote users to think narrowly about the technology in terms of its relevance to their home and whether it is voluntary or not. Such narrow considerations could be circumnavigated, however, through a normative framing (or perhaps a co-framing) and an appeal to a collective goal. Materialising collective values and normative goals within the design of the technology may prompt individuals to be motivated by a normative goal as opposed to a purely gain or hedonistic goal.

To consider normative goals within their technologies, developers need to move beyond narrowly construing users as being egoistic, rational actors or *Homo Economicus* (Strengers, 2014). Indeed, the limitations of using extrinsic rewards for behaviour change, such as their limited ability to influence long term attitudinal changes (Steg & Vlek, 2009) or motivate other environmentally beneficial behaviours (i.e. spillover; Steinhorst et al., 2015), suggest that campaigns for smart technologies with a collective benefit would have greater long term success appealing to environmental citizenship values than to external rewards or punishments (Dobson, 2007). Therefore, there needs to be consideration of how users can be encouraged to take greater responsibility for achieving collective goals, how users can be encouraged to transcend their personal interests for the benefit of others, and how these self-transcending values can be materialised and supported in the design and promotion of the smart technologies (Evans et al., 2013; Le Dantec et al., 2009; Shilton, 2010; Stern et al., 1999).

7.1.3 Empowering citizens through greater control

Priming individuals to think in terms of collective goals and normative behaviours will require individuals to feel empowered to influence the outcome of the goal through their own individual actions. For instance, an interpretation of the findings of Study 3 suggest that the HEMS may be seen as a chance to gain greater control or influence the normative goal of load shifting. Across Studies 2a, 2b, and 3, participants, on average, did not perceive themselves as having control over their neighbours' energy consumption. However, this perception only had an influence on *Perceived Usefulness* for the participants in the normative goal-frame condition of Study 3 and not in the gain goal-frame condition (or Studies 2a or 2b). In the Normative Goal condition of Study 3, *Perceived Control* over neighbourhood energy consumption negatively influenced *Perceived Usefulness* of the HEMS suggesting that the less control the participants perceived themselves as having, the more useful they perceived the HEMS to be. These findings regarding the impact of the normative goal on *Perceived Control* in Study 3 warrant further discussion.

The normative goal-frame may have primed participants to consider their *Intention to Use* the HEMS and load shift at a social, normative level e.g. "we need to do this to reduce UK energy consumption". As such, the participants' lack of *Perceived Control* over their neighbourhood's energy consumption became a predictive factor because the ability to respond to and influence the neighbourhoods' energy consumption will be salient in determining the participants' ability to pursue the normative goal. In contrast, the gain goal-frame may have primed participants to consider their *Intention to Use* the HEMS and load shift at an individual, gain level e.g. "I could do this to save myself money". As such, consideration of the neighbourhood's energy consumption was not necessary for pursuing a gain goal.

It has been shown in previous research that using an energy management technology can lead to users of the technology to consider their level of control over achieving energy reduction targets. In a study by Hargreaves et al. (2010) they found that the information offered by energy management devices (and the subsequent increased awareness of electricity issues) led some users to consider their ability to influence energy consumption within in a broader social and political context. This led them to feel that they were not able to have any impact in the face of the perceived insurmountable social, political, and environmental challenges. As such, the users experienced a sense of fatalism, despondency, anxiety, and guilt. In contrast, other users in the study considered what using the technology could do for them personally. This lead them to feel an increased sense of control and that they were empowered to "take stronger action to reduce *their own* energy consumption" (p. 6119; emphasis added). As such, users felt that making energy savings would easier, more desirable to do, and a normal part of energy consumption.

The study by Hargreaves et al. (2010) could suggest that smart energy technologies can increase the perception of control of energy reduction goals at the individual level, but they may prompt a decrease in perceptions of control when the energy challenges are considered at a higher, societal or political level. The normative goal-framing of load shifting and the HEMS may have primed the participants to consider the energy consumption at this higher level and so their perception of the usefulness of the HEMS was affected by it. Consequently, whilst the evidence of this thesis points towards the benefits of priming broader UK goals, there is a risk that doing so may lead to inaction as individuals could feel their ability to contribute to the goal is minimal. Indeed, this is often the reason given by people for their inaction regarding a number of large scale challenges, such as climate change (e.g. Lorenzoni, Nicholson-Cole, & Whitmarsh, 2007). Feeling unable to have an influence has also been given as a reason to not engage in energy reduction efforts e.g. "it's one house and if we do change something it won't make a vast amount of difference–so we don't bother" (Hargreaves et al., 2010, p. 6118).

Given the risk of reducing individuals' perceived control or influence, it is interesting that in the Normative Goal condition of Study 3, the perceived lack of control was found to increase the perceptions of the usefulness of the HEMS. This is in contrast to the Hargreaves et al. (2010) study, which found that the energy device decreased users' perceived influence over achieving energy reduction, which in turn reduced their use of the energy device. However, it may be that participants in the Normative Goal felt that the HEMS could actually increase their (perceived, limited) control over achieving the normatively framed goal of load shifting to help reach UK targets, and therefore the HEMS was useful to them. This explanation would be predicated on the assumption that the participants wanted to be able to have greater control or influence in achieving the normative goal (i.e. be active users and load shift). The alternative explanation, however, is that individuals felt that the technology would be able to do something for them that they felt unable to do (i.e. it is useful because it can control what they cannot). This explanation would then suggest that the participants wished to give responsibility for ensuring the success of the normative goal to the technology i.e. be passive users and let the technology manage the load shifting.

Perceiving the technology as useful because it could provide greater control would be in keeping with the outcomes that the interviewees of Study 1 desired. The interviewees felt that smart technologies should be used to empower citizens to be active and participatory within the smart city. If citizens do not feel they have any control over the outcomes of smart city strategies (such as reducing energy consumption) then the smart technologies may in fact disempower them and discourage them from using the technology. In this scenario, citizens may become passive and prefer smart technologies to be automated.

The potential for smart energy technologies to make users feel disempowered and that their electricity reduction efforts are futile (Hargreaves et al., 2010) may be mitigated if individuals are given empowering messages whilst interacting with the smart energy technology. For instance, Gonçalves et al. (2013), sent psychologically empowering messages to users of a mobile phone app for reporting local issues to their local authority. The empowering messages focused on increasing the users' causal importance and self-efficacy. Those users who received the empowering messages used the app more frequently than users who only received reminders. Therefore, empowering users to feel like their actions are important and able to influence societal and political outcomes may be an important component to increasing their acceptance and utilisation of smart technologies as well as ensuring that users actively use the technology to pursue the goals, rather than passively rely on it to achieve the goals for them.

In sum, a perceived lack of control when pursuing a normative goal may promote the usefulness of a smart technology. However, further research will be needed to explore whether it is for greater control over the goal (e.g. being active) or the relinquishing of responsibility for the goal that users are seeking (e.g. being passive). Furthermore, it should be noted that if users wish to have greater control, but then do not feel the technology gives them enough influence to make a difference, then a lack of perceived control may lead to despondency or inaction. As such, it will be important to accompany the distribution of smart energy technologies, such as the HEMS with psychologically empowering messages of control, causal importance, and self-efficacy in order to prompt (empower) users to take responsibility for achieving the collective goal.

7.1.4 Theoretical Implications for the TAM and Exploratory Factors

As discussed in Studies 2a and 2b (section 5.10.2), the significance of *Perceived Usefulness* and *Perceived Ease of Use* across the three studies is consistent with existing studies that have used the original TAM (e.g. W. R. King & He, 2006). Interestingly, the findings of this thesis not only support the original TAM model, but also demonstrate the effectiveness of the model for predicting acceptance of smart energy technologies for the home rather than the workplace[7]. In addition, the TAM2 variable of *Home Relevance* was both a direct and indirect predictor of *Intention to Use* across all the studies. As such, future studies using the TAM to investigate the acceptance of technologies for home use, should include *Home Relevance* within the model.

The other variables found to be predictive of intention to use, including the TAM2 variables and the exploratory augmenting variables, were found to be less consistent across the studies and would appear to be more dependent on the context provided by the information. As such, the psychological empowerment variables of *Goal Internalisation* and *Perceived Control,* should be included within models exploring technologies which require a prosocial action from the user. In particular, *Goal Internalisation* could be used to explore the potential moderating effect of a collective goal on individual goals. In addition, *Environmental Citizenship,* and *Environmental Concern* should be included in models where the outcome of using the technology has potential proenvironmental outcomes as the studies suggest there is potential for environmental values and actions to predict future intentions.

In terms whether the addition the exploratory variables to the TAM2 improves the explanatory power of the TAM2 models, inspection of the R^2 values (all R^2 values for all models are available in Appendix M) suggested that the exploratory variables only contributed to a small increase in the explained variance. It is perhaps fairer to compare the TAM2 with only the significant variables entered into the model (as opposed to the model with all the TAM2 variables entered) to the augmented and moderated models as having more variables in the regression inflates the R^2 values (Field, 2009). Comparing the models with only the significant predictors shows that from the TAM2, to the augmented TAM2, to

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[7] As outlined in Chapter 5, in previous studies, the TAM has previously been predominantly used to explore acceptance of workplace technologies by employees, e.g. (Schepers & Wetzels, 2007).

the moderated model, there is either no increase in the R^2 values or an increase of approximately .02 (2%). The exception is in study 2b where there is a drop in the *Perceived Usefulness* model from .76 in the TAM2 (only significant predictors) model to .71 in the moderated model. Despite only modest increases and the decrease in explained variance, the addition of the exploratory variables and the moderator are still informative. These studies were exploratory in nature and sought to not only test the TAM2, but also to explore the importance of the variables that may be important to becoming smart citizens. Therefore, finding that *Goal Internalisation* is a negative moderator (among the other findings) is meaningful, despite adding a potentially, statistically non-significant amount of variance explanation to the model.

Overall, for exploring energy management technologies in the home, the original TAM plus *Home Relevance*, *Goal Internalisation*, *Perceived Control*, *Environmental Concern* and *Environmental Citizenship* could provide an informative model for predicting *Intention to Use* the energy technology. This comes with the caveat that the technology is future based and user experience is not possible. If user experience is possible, further TAM2 factors, such as *Result Demonstrability* and *Social Norms* may be influential (for the reasons outlined in Chapter 5, section 5.10.1) and should also be included.

7.1.5 Implications for Policy

In addition to the implications discussed above, there are number of other implications for policy that will now be discussed. For instance, whilst economic frames are often used for smart energy technologies (Bolderdijk et al., 2013; Evans et al., 2013), the "Smart Energy GB" campaign has been set up by the UK government to inform UK residents about smart meters. The information on this website uses both “Benefits for You” and “Benefits for Britain” to explain smart meters (Smart GB, 2016). Therefore, there are attempts within the UK smart metering strategy to frame smart meters with shared, normative goals. As discussed above, considering smart meter acceptance is currently voluntary in the UK, the normative goal-frame will be important for reducing the influence of more egoistic, pragmatic considerations in acceptance of the technology. Therefore, whilst it is promising that the campaign website is using normative goals, it will be important to promote this aspect of the campaign beyond only a website.

Some of the ways in which smart city literature discusses empowering citizens is through making data available to citizens. Such approaches make the flawed assumption that the provision of information will in turn automatically engage and motivate citizens (essentially a knowledge deficit argumentBrunk, 2006). Empowering and engaging citizens is more than just making forms available to download from a website (Caragliu & Del Bo, 2012), or displaying information on a city dashboards (Kitchin, 2014), urban screens (Bobker, 2011; Kitchin, 2014; Schroeter, 2012; Struppek, 2006) or mobile apps (Boulos et al., 2011; Janarthanam et al., 2012). These approaches only cater for the individuals who are already motivated, feel responsible, and feel able to influence change e.g. environmental citizens (Dobson, 2007; Luque, 2005). As such, these information provision based approaches contribute very little to individuals who are not motivated to seek the information, do not feel any responsibility to act on the information, and/or do not feel able to have any influence in the city. Empowering citizens is about increasing the perceived control over the city objectives and motivating them to share the objectives, as such it is about facilitating psychological empowerment. Campaigns for introducing new smart technologies into cities and homes should use messages that focus on emphasising how pursuing the goal will benefit everybody and they, as an individual citizen can use the technology to have an influence in achieving the goal for city (e.g. Gonçalves et al., 2013).

Citizens sharing goals also has implications for how sustainable or pro-environmental behaviour is encouraged by local and national governments. For instance, government legislation and regulation to change behaviours may be perceived as controlling and reduce motivation or prevent citizen autonomy (Lavergne et al., 2010). In a Canadian study, Lavergne et al. (2010) found that citizens who perceived the government as controlling experienced amotivation and controlled motivation (i.e. only acting because they felt they had to). Subsequently, perceiving the government as controlling was negatively correlated with pro-environmental behaviours. In contrast, citizens who felt that the government was not controlling and in fact supported citizen autonomy, felt more motivated. In addition, perceiving the government as autonomy-supportive positively contributed to pro-environmental behaviour. Indeed, studies of mentoring students have found that supporting autonomous goal pursuit is associated with greater perseverance and better performance than being overly controlling (Deci & Ryan, 2000). Therefore, inspiring citizens to contribute towards a collective goal and then supporting their autonomous pursuit of it (through smart technologies or other methods), may lead to greater citizen motivation for the goal pursuit than simply enforcing it through legislations or regulations.

7.1.6 Limitations and Future Directions

As with any research, there are limitations to the findings of this research. For instance, in Studies 2a, 2b and 3, there was a lot of information for the participants to comprehend, process, and factor into their perception formation. This amount of information was needed, as to explain, in a fair and accurate way, the need for the HEMS and load shifting/energy reduction and what participating in them would entail, required detail. It is an important feature of the ICQ approach that the participant is able to use the information to make a fully informed response (ter Mors et al., 2013). It may be that participants did not read all the information fully, and the high drop-out rates of Studies 2a and 2b suggest that some participants were unwilling to engage with so much information.

To some extent, the large amount of information in the questionnaires replicates the "real world" situation in which consumers will be evaluating technologies, where a large range of information (and misinformation) will be available to them (Häubl & Trifts, 2000; ter Mors et al., 2013; Terwel, ter Mors, & Daamen, 2012). This is particularly true of smart energy technologies due to the potential complexities of load shifting and current energy issues (Pidgeon, Demski, Butler, Parkhill, & Spence, 2014). The strength of the ICQ approach is the responses are based on informed decisions and therefore, they do not represent the responses of the population are, but what they could be, if they received such information (de Best-Waldhober et al., 2009).

It is important to consider that, whilst there were consistent predictors of intentions to use the HEMS across the studies, there were still differences in the predictors. This has the implications discussed within the findings of the studies, but it also highlights the fact that participants' responses to the HEMS were predominantly based on the information. If very different information was provided in the questionnaires to explain the HEMS, then it could alter the participants' perceptions of the HEMS. This was why it was necessary to ensure the information provided in the questionnaires had been validated and checked by experts for accuracy and lack of bias. As noted in the discussion of Study 2, it is not possible to know which aspects of the information the participants were responding to when forming their perceptions i.e. which segments of information lead to the positive perceptions found across the studies of this thesis. Qualitative work may be most suited to explore this question or an approach such as “Think Aloud” (McDonald, Zhao, & Edwards, 2015) in order to explore the most salient or pertinent aspects of the HEMS for participants when they are assessing the relevance, usefulness, and ease of use of the HEMS.

It is common for intention to use being measured in the TAM, but not the actual usage (W. R. King & He, 2006) and there is a relationship between intentions to use and actual usage (Turner et al., 2010). However, it will still be important to explore the findings of this thesis with actual potential users of HEMS for load shifting. For example, the divided experiences of control found by Hargreaves et al. (2010; discussed above), may highlight a limitation of asking individuals about anticipated, or expected, use of a smart energy technology compared with actual use. Perhaps, in principle, individuals could feel a technology will give them greater control (as potentially indicated in Study 3), but the reality of using it might lead to feelings of powerlessness and futility. As such, future research could explore the influence of *Perceived Control* on the actual usage of smart energy technologies, and actual load shifting behaviour; particularly over time. It might be expected for a normative goal, that a perceived lack of control initially increases the technology usage (to seek control), but the user may become disempowered over time if they feel they are not able to influence the energy consumptions problems (i.e. achieve the normative goal).

It would also be necessary to explore whether individuals want to have greater influence and control over achieving energy reduction targets or not. This would help to understand the negative effect of *Perceived Control* on *Perceived Usefulness*. Individual differences between those who wish to have control and those who do not could then be explored. This would then help the discussion of whether smart citizens are those who are empowered through technology to be active and participatory in smart city strategies or whether smart citizens are those who are disempowered through technologies and so are passive and non-participatory. Equally, it would be of value to explore *Goal Internalisation* further to understand the processes of internalising and sharing a goal and its influence on the user.

It should be noted that conducting research on the HEMS and load shifting, or other technologies with implications for the user, whilst they are still hypothetical scenarios is important, despite the unknown transferability to actual usage. This is because the public acceptance of technologies is often explored after the technology's commercialisation and once public concerns have already been raised, such as with nuclear power, wind turbines, or genetically modified crops (Nidhi Gupta, Fischer, & Frewer, 2011). Therefore, the technologies have already become a controversial topic, which increases the likelihood of rejection from the public. Greater engagement and discussion with the public further 'upstream' in the design and consideration stage of technologies can reduce concerns and ultimately foster greater acceptance (Bussu, 2014; Sanders & Stappers, 2008). Therefore, identification of factors influencing acceptance of future technologies may help to inform the technology design and commercialisation process. Further research should explore the public perceptions of future smart technologies with potentially controversial implications, such as load shifting, in order to reduce controversy once commercialised.

The findings of this thesis, whilst exploratory, point to goals and goal internalisation as having a role in the acceptance of smart energy technologies. Literature on Self-Determination Theory (SDT; Deci & Ryan, 2000) could be used to further explore and understand the role of goal internalisation in acceptance of smart technologies. For instance, an important aspect of sharing a goal will be the extent with which it is internalised by the individual. The extent of the goal internalisation determines how the individual pursues the goal. For instance, if individuals value the goal or see the goal pursuit as representing their self-concept (termed identification and integration, respectively) then the goal is fully internalised and the individual will pursue the goal with perseverance and engagement. In comparison, if the individual does not value the goal and only pursues it due to external forces or internalised social pressures (termed external regulation and introjection, respectively), then the goal will not be internalised and the individual will not pursue the goal with as much perseverance, engagement, or success (Deci & Ryan, 2000; Gagné & Deci, 2005; Webb, Soutar, Mazzarol, & Saldaris, 2013). SDT could allow for a distinction between citizens participating and engaging with the goals of the city because they value the goal, compared to those being made to behave in line with the goals of the city through legislation or regulation.

Further to those explored in this thesis, additional potential influences on the acceptance of the HEMS can be identified from the literature and could be explored in future studies. For instance, in literature on the public acceptance of technologies, perceived risk, trust, perceived benefits, knowledge, individual differences, and attitude have most commonly been explored (Gupta, Fischer, and Frewer, 2011). With regards to the HEMS, risk and trust may have particular relevance to smart technologies as household smart technologies, such as smart meters, have led to concerns for privacy and/security due to a perceived potential for misuse of data (McKenna, Richardson, & Thomson, 2012). In relation to load shifting, the issue of trust has been raised in focus groups. For instance, Spence et al. (2015) found that users may mistrust the ability to save money from load shifting and Ilic et al. (2012) found that potential users did not trust network operators to have control over when they can or cannot use electricity Therefore, trust may be an influential factor in technology acceptance. Indeed, Suh and Han (2003) found greater trust in internet banking increased participants' intention to use internet banking. Therefore, inclusion of participants' trust regarding the developers of the technology and its implications, may predict intention to use the HEMS.

With regards to risk, Im, Kim, and Han (2008) found that perceived risk moderated the effect of *Perceived Usefulness* on *Intention to Use,* with greater risk perception reducing the effect of *Perceived Usefulness.* In their study, perceived risk was assessed in terms of whether using the technology would be worth the cost, whether it would be frustratingly poor performing, whether it has too many uncertainties, and whether it would be effective. These issues may be relevant to concerns for the HEMS, which as a new household technology with potential implications data security or disruption to energy consumption habits or preferences, may be considered not worth the risk and therefore not used. As such, exploring perceived risk as a moderator of the perceived usefulness HEMS would be informative as to the conditions in which perceived usefulness is most influential on intentions to use the HEMS.

To take a broader perspective of future research on citizens and future cities, the exploratory work of this thesis may provide some direction for how future work on citizens and smart cities could be approached. The research for this thesis intended to apply environmental psychology research practices to the large scale challenges of urbanisation. These challenges are most often considered in terms of physical space and policy (such as with urban studies, e.g. S. Fox & Goodfellow, 2016) or at the level of society and meaning (such as with sociology, e.g. Kharlamov, 2012). The studies in this thesis, however, considered the attitudes and intentions of the individual in relation to wider, normative and collective goals, and their role as a citizen of a smart city. As such, it was exploratory in nature and challenging in its reconciliation of psychological and urban studies perspectives.

Future work could use a transdisciplinary approach to research smart cities and their citizens. Transdisciplinary research is based on the argument that unidisciplinary, multidisciplinary, and interdisciplinary practices must evolve in order to be able to tackle the increasingly complex challenges in research and society (Ramadier, 2004). It is an approach which aims to transcend traditional disciplinary boundaries in order to develop holistic understanding of societal problems, create new analytical frameworks, and conduct problem-focused research to solve societal issues (Frescoln & Arbuckle Jr, 2015; Lang et al., 2012; Pohl, 2008). Therefore, a transdisciplinary approach could be used to articulate the experience of the smart citizen at a physical, sociological, and behavioural level (i.e. the traditional fields of urban studies, sociology, and psychology) by deconstructing and integrating theoretical and methodological approaches, such as from urban studies, sociology, and environmental psychology, as well as human computer interaction (HCI) or computer science disciplines (Ramadier, 2004). As smart technologies increasingly connect the individual to wider social and information networks, the role of the citizen in achieving sustainability and "smartness" will continue to expand. Therefore, it will be important to evolve research practices accordingly and develop the understanding of individual citizens working within a digitally-enabled, smart city to achieve the collective, shared goals of sustainability.

7.2 CONCLUSIONS

There is growing interest in the potential to achieve resource efficiency through smart technology. However, literature suggests that smart technologies and citizens will need to co-evolve in order to support new forms of resource management. This thesis developed testable hypotheses of the characteristics and indicators that may allow a further understanding of the smart city developments from the perspective of the citizen. Understanding how individuals perceive themselves in the smart city system, and how this perception will influence their acceptance of the smart agenda, will be important for future research to explore. This is because the scale of the urbanisation and sustainability challenges will mean individuals will need to act for the benefit of the collective and not just the individual. Currently, smart technologies are envisioned as having a large role in enabling and facilitating this citizen action. However, whether this is through the empowerment of smart citizens through greater participation, shared goals and greater responsibility or the disempowerment of smart citizens through technocracy, top-down goals and automation, will depend on how smart city leaders incorporate citizens into their strategies and how the technologies are framed.

The findings of this thesis demonstrate the importance of personal, home energy goals in the acceptance of smart energy management. The research further suggests that the internalisation of wider collective national or city goals will be a critical aspect of citizen engagement and empowerment within the smart city and is likely to be important in supporting the roll out of smart technology. Therefore, more broadly, the research of this thesis supports the need to use normative, shared goals within smart city strategies and empowering citizens to feel able to contribute to the achievement of the goal. What it means to be a smart, empowered citizen, therefore, is one who shares the collective goals, and gains greater control and influence over achieving those goals (such as for sustainability) through the use of smart technologies.

Chapter 8: References

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Chapter 9: Appendices

9.1 Appendix A: Coding Manual for Study 1 Interviews

Coding Manual for Interviewees of Study 1	
Air Quality	When air quality concerns/issues/solutions in the city are discussed.
Attractivity	Topics relating to making the city an attractive place to live, work and play
Automated cities	Discussion of computers controlling aspects of the cities and citizens.
Behaviour Change	Any discussion of changing citizens' (peoples') behaviours.
Bottom-Up Approach	Discussion of communities or people developing their own initiatives without government input.
Challenges of Implementing Technologies	Discussions of things which make getting technology into cities and homes difficult.
Change in Social Norms	Topics relating to changing societal norms and values – changing what is considered normal.
Changes to Working life	Any discussion of how citizens' working life may change.
Citizen Awareness of City Developments	Citizen awareness of general developments in their city
Citizen Awareness of Sustainability	Discussion of citizens' awareness about the need for sustainability in their city
Citizen Awareness of Technology (Nodes)	Discussion of the citizens' knowledge and awareness about technology in the city or home.
Citizen Choices	Discussion of how much choice and the types of choices they will have.
Citizen Disempowerment	Discussion of things that will take power, take choice, take the ability to be involved away from the citizen.

Citizen Empowerment	Discussion of things that will empower the citizen, give them choice, enable them to take part of do things differently.
Citizen Lead Change	Wherever citizens (people) are seen as being (or needing to be) the instigators or leaders of changes.
Citizens working with Energy Companies	Topics relating to citizens having greater interaction with energy companies
Citizenship	Feeling of belonging to and responsibility for community and city
City awareness of citizens	Discussion of the city's awareness of the citizens' needs
Communication of Message to Citizen	Relating to how the city talks to its citizens and what it should talk to them about.
Communities Coming Together	Discussion of how communities can work together or the importance of communities
Communities Using Data	How communities can use data from the city in order to question, make demands and change their community.
Companies Pushing Technologies	How technology companies sell their technology to cities.
Competing Considerations	Discussions of how benefit to one things may mean be damaging to another thing.
Connecting Infrastructure	Use of computers and analysis to connect buildings, homes, hospitals, services, transport etc. so that they can share information.
Creative Uses of Technology	When citizens use technology in unexpected ways.
Culture	Any impacts, changes or discussions of culture
Danger of Over-relying on technology	Potential risks or pit-falls associated with increasing technology use
Data Privacy	Discussion of issues of data privacy
Data to Manage the City	Using data collected from sensors or phones etc. to enable the management of city services
Defining Sustainability	Discussions of what sustainability is.

Demanding Citizen	Discussion of the citizen role and being involved in decision making and demanding changes.
Dialogue between City and Citizen	Two-way communication between the citizens and the city councils/government. Feedback.
Difficulties in being Sustainable	Challenges to improving sustainability
Digital Divide	Danger of some people being able to use and access data and technologies whilst some are unable for whatever reasons.
Domestic Renewables	Any mentions of energy generation or storage at peoples' houses/
Economic Barriers	Barriers to future cities that are economic in nature
Economic Benefits of Developments	Discussion of potential benefits to the economy from developments in the city.
Emission Targets	Discussion of emission targets
Energy Prices	Discussion of energy prices
Engaging Citizens	Any discussion of engaging citizens in the city and methods that might be employed
Environmental Challenges	Environmental challenges faced by cities.
Environmentally Conscientious Citizen	Discussion of citizens who care about the environment and their impact in it.
Evidence Base Required	The need for evidence to be collected about the effectiveness of the different interventions.
Failure to Use Technology	Danger of people not using the provided technologies.
Incentivising	Any discussion of how people might be incentivised to change behaviour
Inclusion of People	Involving people within the city developments/initiatives
Increasing Efficiency	Discussions of improving efficiencies within the city, e.g. reducing the energy used.
Internet Connectivity	Relating to the internet connecting people, buildings etc.
Intuitive use of technology	Discussion of how people will use technology and data in the future

Involving Citizens in Technology Development	The need for citizens to be considered in the design of technologies
Literacy	Discussion of peoples' knowledge and understanding relating to the environment, technology or sustainability.
Living Labs	Discussion of living labs
Making Sustainability Appealing	Discussions of making sustainability easy or beneficial or pleasant
Mobile Phones	Any issues relating to mobile phones e.g. as sensors, GPS tracking or communicating.
Motivations for using tech to reduce energy	Discussion of peoples' motivations for wanting to use technologies
Not Using Technology for Change	Discussion of methods or initiatives where technology is not used in any way
Old City Infrastructure	Mentions of the existing and out-dated infrastructures and their consequences
Open Data	Any discussion relating to the provision of data to the citizens/giving citizens access to city data.
Participatory Citizen	Citizens voting and influencing city decisions
Political Challenges	Political difficulties in city developments
Preventing Environmental Impact	When reducing environmental impact is discussed.
Public Transport	Issues relating to public transport
Quality of Life	Any discussion of citizens quality of life, their happiness, their well-being etc.
Rebound Effects	Discussions of people using more energy as a result of making things easier to use e.g. driving more because congestion is reduced.
Responsibility	Citizens taking responsibility for their energy use and environmental impacts
Smart Grids	Any mentions of smart grids
Smart in a Smart City	Discussions of "smartness" or what makes a city "smart"
Smarter Transport	Discussion of using technology to improve transport

Social Acceptance	Issues around people accepting developments
Social Media	Discussions of social media
Technology Accessibility	Issues relating to people being able to access technologies
Technology Adoption	Discussion of peoples' acceptance and use of technologies
Technology Connecting Communities	Where technology is used to inform communities and enable community initiatives
Technology enabling smartness	When technology is discussed as enabling smarter decisions etc.
Technology Enabling Voting	Use of technology to get people voting
Technology improving lives	Using technology to improve quality of life in some way
Technology Localising City Functions	Things like decentralisation, micro-renewables etc.
Technology to change behaviour	Use of technologies and data to influence people
Technology to reduce energy usage	Technology to make people, processes, services etc more efficient and reduce their energy.
Technology to tackle challenges	General discussions about technology being used to tackle challenges in the city.
Top Down	Discussion of initiatives which are led by government or council, little citizen involvement
Transport Challenges	Challenges surrounding city transport
Urbanisation	Increasing numbers of people moving to the city and its problems
Future City Concepts	Discussion of the future city concept definitions
Vision for City Future	Broad visions for how cities will be
Walkable Cities	Bit of a one of- the fact we can walk in UK cities
Working Together	The idea that all levels of the city e.g. council, citizens, industries etc. should work together on initiatives.

Instructions for Second Coder

If there is a question before the paragraph/sentence you are coding, then include the question in the coding.

Paragraphs/Sentences can have more than one code.

Some codes may be used more or less frequently than others.

Suggestion- Read the whole paragraph (maybe more) without coding and then go back and code.

9.2 Appendix B: Staff email invitation for Study 2

Dear staff,

We would be really interested to know what you think about energy use in your home and some of the future energy management technologies that will soon be available to you.

We have put together a questionnaire which explains the energy technologies and then asks for your views on them.

To say thank you for your completion of the questionnaire, we will enter you into a prize draw to win a either a #100, a #50 or one of three #10 Love2Shop vouchers, which can be used in a whole range of shops. It will take you approximately 16 minutes to go through and should be interesting and informative to boot.

If you would like to enter, then please follow this link:
https://academictrial.az1.qualtrics.com/SE/?SID=SV_bxrpdNljGK7eaUZ

This research has received ethical approval from the Department of Psychology Ethics Committee and is supervised by Dr Christopher Jones. Any questions regarding the research should be sent to xxx@shef.ac.uk.

Many thanks for your interest.

Kind regards,

Colin Whittle

(PhD student, E-Futures)

9.3 Appendix C: Informed Questionnaire for Study 2a

Home Energy Management

Energy Reduction

At the moment, we burn coal, gas and oil for heat and electricity. These are finite resources, which mean there is a limited supply of them and one day they will run out. When this happens we will no longer be able to use them to make electricity or heat.

Also as coal, gas and oil are burned they release gases like carbon dioxide and nitrogen oxide which go into our atmosphere. These are called 'Greenhouse Gases'. These Greenhouse Gases will cause dangerous changes to our climate.

Government leaders in the UK and the rest of Europe have agreed that in order to reduce the impacts of climate change we need to reduce the amount of greenhouse gases being released between now and 2030. One of the ways to achieve these targets means burning less coal, gas and oil.

Renewable energy resources, such as wind and solar energy, offer forms of energy that do not run out and do not directly produce greenhouse gasses. These renewable energies could be used instead of coal, gas and oil.

However, using the renewable energies is only part of the solution. It will also be very important to reduce the demand for electricity in homes and businesses. Less demand for electricity would mean that not as much electricity needs to be produced. For this reason, the government and researchers are trying to find ways to help everyone reduce their electricity usage within their homes and cities.

Next you will find a description of a new technology that will help you monitor your energy use....

Please read through this information carefully, even if you have heard of the technology before.

Home Energy Management Systems (HEMS)

One idea to help you reduce your electricity usage within your home is to use technologies to make electricity usage more "visible" and easier to keep track of.

New Smart Meters are already being put into peoples' homes in the UK. They will replace the current electricity meter in your home. These Smart Meters can send information to your energy company about exactly how much electricity you are using across the day. This information means the energy company can do automatic meter readings. This means you get more accurate bills.

Once you have a Smart Meter, you could also get a Home Energy Management System (HEMS). Your Smart Meter can send information about the electricity you are using to the HEMS. The HEMS will then display your electricity usage on its screen, as shown in the picture below.

Having a HEMS mean you will be able to see much electricity you are using at that moment and how much you have previously been using. You could see how much you used on the same day last week or even last year. This electricity usage information could be shown to you either in units of electricity (kilowatts) or price (£). It could also be shown as numbers or in a graph.

Keeping track of how much electricity you are using from one minute to the next like this is called real-time monitoring.

Technologies such as the HEMS could help you to be more aware of when and how you use energy in your home. This awareness could help you to reduce the amount of energy you use. Reducing your household energy use will slow down the use of the finite resources, help the UK to reach its targets for 2030 and help reduce the risks of climate change. .

One way you can get a better idea and understanding of how much electricity you are using in your home is by seeing how much people in your neighbourhood are using.

HEMS could also show you how much energy is being used by your neighbours and compare it to your own. The idea is that by being able to compare your energy use with that of your neighbours, you might be encouraged to reduce your electricity use, particularly if your use is shown to be higher as compared to others in the neighbourhood

Thank you for reading through the information. Based on what you have just read, we would like to know what you think about the Home Energy Management System (HEMS). Please respond to the questions below.

All things considered, use of the Home Energy Management System (HEMS) in my house will be...

	1	2	3	4	5	6	7	
Good	❍	❍	❍	❍	❍	❍	❍	Bad
Wise	❍	❍	❍	❍	❍	❍	❍	Foolish
Favourable	❍	❍	❍	❍	❍	❍	❍	Unfavourable
Beneficial	❍	❍	❍	❍	❍	❍	❍	Harmful
Positive	❍	❍	❍	❍	❍	❍	❍	Negative

Below are a series of statements about YOUR EXPECTATIONS OF the Home Energy Management System (HEMS). Please indicate to what extent you either agree or disagree with the statements.

	Strongly disagree	Modera-tely disagree	Some-what disagree	Neither disagree nor agree	Some-what agree	Modera-tely agree	Strongly agree
Given that I have access to the HEMS, I predict that I would use it.	❍	❍	❍	❍	❍	❍	❍
Assuming I have access to the HEMS, I intend to use it.	❍	❍	❍	❍	❍	❍	❍
Using the HEMS in my house would enable me to control my energy use.	❍	❍	❍	❍	❍	❍	❍
Using the HEMS in my house would improve my energy management.	❍	❍	❍	❍	❍	❍	❍
Using the HEMS in my house would increase my ability to control my energy use.	❍	❍	❍	❍	❍	❍	❍
Using the HEMS would enhance my effectiveness on managing my energy usage.	❍	❍	❍	❍	❍	❍	❍
Using the HEMS would make it easier to manage my energy use.	❍	❍	❍	❍	❍	❍	❍
I would find the HEMS useful in my house.	❍	❍	❍	❍	❍	❍	❍

Learning to operate the HEMS would be easy for me.	❍	❍	❍	❍	❍	❍	❍
I would find it easy to get the HEMS to do what I want to do.	❍	❍	❍	❍	❍	❍	❍
My interaction with the HEMS would be clear and understandable.	❍	❍	❍	❍	❍	❍	❍
I would find the HEMS flexible to interact with.	❍	❍	❍	❍	❍	❍	❍
It would be easy for me to become skilful at using the HEMS.	❍	❍	❍	❍	❍	❍	❍
I would find the HEMS easy to use.	❍	❍	❍	❍	❍	❍	❍

A few more statements about Home Energy Management Systems (HEMS)

	Strongly disagree	Modera-tely disagree	Some-what disagree	Neither disagree nor agree	Some-what agree	Modera-tely agree	Strongly agree
I feel my use of HEMS would be voluntary.	❍	❍	❍	❍	❍	❍	❍
My government does not require me to use HEMS.	❍	❍	❍	❍	❍	❍	❍
Although it might be helpful, using HEMS is certainly not compulsory for my home.	❍	❍	❍	❍	❍	❍	❍
People in my neighbourhood who use HEMS have more prestige than those who do not.	❍	❍	❍	❍	❍	❍	❍
People in my neighbourhood who use HEMS have a high profile.	❍	❍	❍	❍	❍	❍	❍
Having HEMS is a status symbol in my neighbourhood.	❍	❍	❍	❍	❍	❍	❍

In my home, usage of the HEMS would be important.	❍	❍	❍	❍	❍	❍	❍
In my home, usage of HEMS is relevant.	❍	❍	❍	❍	❍	❍	❍
The quality of the output I would get from HEMS sounds like it will be high.	❍	❍	❍	❍	❍	❍	❍
I have no problem with the idea of the HEMS' output.	❍	❍	❍	❍	❍	❍	❍
I would have no difficulty telling others about the results of using HEMS.	❍	❍	❍	❍	❍	❍	❍
I believe I could communicate to others the consequences of using HEMS.	❍	❍	❍	❍	❍	❍	❍
The results of using HEMS are apparent to me.	❍	❍	❍	❍	❍	❍	❍
I would have difficulty explaining why using HEMS may or may not be beneficial.	❍	❍	❍	❍	❍	❍	❍
People who influence my behaviour would think that I should use HEMS.	❍	❍	❍	❍	❍	❍	❍
People who are important to me think that I should use HEMS.	❍	❍	❍	❍	❍	❍	❍

Thank you, you're responses are really helpful! On the next page is the second of the two technologies...

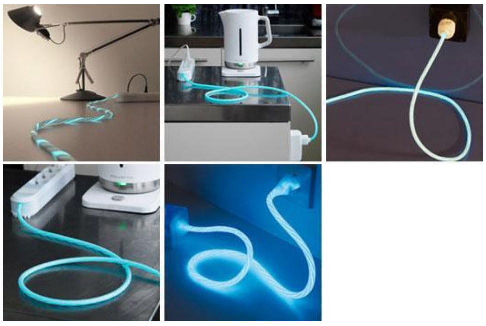
Great! Once again, please carefully read the information below.

Ambient Interfaces

A slightly different way to tell you about your energy usage is to use "ambient interfaces". These are technologies that use only lighting, imagery or sounds to tell you information, rather than numbers, words or graphs.

One example is a power cable that glows blue when it has electricity running through it (see image 2 below). This is intended to help you avoid wasting energy and encourage you to use less energy by reminding you that electricity is being used.

Ambient interfaces don't show how much energy is actually being used in terms of numbers. Instead they change in their brightness or colours. This can visually show you that you are using more or less energy. For example the power cord in Image 2 will glow a brighter blue when more electricity flows through it. This power cord uses no more energy than a normal power cord as the glow comes from a special material reacting with the electricity.



Other ideas for ambient interfaces include glowing orbs or plastic plants that grow or wilt depending on usage.

That's the end of the second technology! We'd now really like to know what you think of it....

Thank you for reading through the information. **Based on what you have just read**, we would now like to know what you think about the Ambient Interfaces. Please respond to the questions below.

All things considered, I think that the use of Ambient Interfaces in my house will be...

	1	2	3	4	5	6	7	
Good	❍	❍	❍	❍	❍	❍	❍	Bad
Wise	❍	❍	❍	❍	❍	❍	❍	Foolish
Favourable	❍	❍	❍	❍	❍	❍	❍	Unfavourable
Beneficial	❍	❍	❍	❍	❍	❍	❍	Harmful
Positive	❍	❍	❍	❍	❍	❍	❍	Negative

Next we have a series of statements about YOUR EXPECTATIONS OF the Ambient Interfaces. Please indicate to what extent you either agree or disagree with the statements.

Using Ambient Interfaces would make it easier to manage my energy use.	❍	❍	❍	❍	❍	❍	❍
I would find Ambient Interfaces useful in my house.	❍	❍	❍	❍	❍	❍	❍
Learning to operate a Ambient Interfaces would be easy for me.	❍	❍	❍	❍	❍	❍	❍
I would find it easy to get Ambient Interfaces to do what I want to do.	❍	❍	❍	❍	❍	❍	❍
My interaction with Ambient Interfaces would be clear and understandable.	❍	❍	❍	❍	❍	❍	❍
I would find Ambient Interfaces flexible to interact with.	❍	❍	❍	❍	❍	❍	❍
It would be easy for me to become skilful at using Ambient Interfaces.	❍	❍	❍	❍	❍	❍	❍
I would find Ambient Interfaces easy to use.	❍	❍	❍	❍	❍	❍	❍

A few more statements about Ambient Interfaces...

	Strongly disagree	Modera-tely disagree	Some-what disagree	Neither disagree nor agree	Some-what agree	Modera-tely agree	Strongly agree

I feel my use of Ambient Interfaces would be voluntary.	❍	❍	❍	❍	❍	❍	❍
My government does not require me to use Ambient Interfaces.	❍	❍	❍	❍	❍	❍	❍
Although it might be helpful, using Ambient Interfaces is certainly not compulsory for my home.	❍	❍	❍	❍	❍	❍	❍
People in my neighbourhood who use Ambient Interfaces have more prestige than those who do not.	❍	❍	❍	❍	❍	❍	❍
People in my neighbourhood who use Ambient Interfaces have a high profile.	❍	❍	❍	❍	❍	❍	❍
Having Ambient Interfaces is a status symbol in my neighbourhood.	❍	❍	❍	❍	❍	❍	❍
In my home, usage of the Ambient Interfaces would be important.	❍	❍	❍	❍	❍	❍	❍
In my home, usage of Ambient Interfaces is relevant.	❍	❍	❍	❍	❍	❍	❍
The quality of the output I would get from Ambient Interfaces sounds like it will be high.	❍	❍	❍	❍	❍	❍	❍

Thank you! This is really great! You're on to the last bit now where we find out what you think about the environment and technologies.

These questions are about any environmentally related activities you are/have been involved in:

	Yes (1)	No (2)
Are you a member of any group whose main aim is to protect the environment?	❍	❍

In the last 12 months have you....

	Yes (1)	No (2)
...read any newsletters, magazines or other publications written by environmental groups?	❍	❍
...signed a petition in support of protecting the environment?	❍	❍
...given money to an environmental group?	❍	❍
...written a letter or called your member of parliament (MP) or other governmental official to support strong environmental protection?	❍	❍
...boycotted or avoided buying the products of a company because you felt that company was harming the environment?	❍	❍
...voted for a candidate in an election at least in part because he or she was in favour of strong environmental protection?	❍	❍

Great! These next questions are about how you feel about energy usage:

	Strongly disagree	Modera-tely disagree	Some-what disagree	Neither disagree nor agree	Some-what agree	Modera-tely agree	Strongly agree
I am inspired by the energy reduction we are trying to achieve in the UK.	❍	❍	❍	❍	❍	❍	❍
I am inspired by the energy reduction goals of the UK.	❍	❍	❍	❍	❍	❍	❍
I am enthusiastic about working towards lower energy usage in the UK.	❍	❍	❍	❍	❍	❍	❍
I can influence the way energy is used in my neighbourhood.	❍	❍	❍	❍	❍	❍	❍
I can influence energy decisions in my neighbourhood.	❍	❍	❍	❍	❍	❍	❍
I have the authority to make decisions in my neighbourhood.	❍	❍	❍	❍	❍	❍	❍
I have the skills and abilities to reduce my energy usage well.	❍	❍	❍	❍	❍	❍	❍
I have the competence to manage my energy usage effectively.	❍	❍	❍	❍	❍	❍	❍

I expect I will adapt my energy use to be at times of lower energy demand.	❍	❍	❍	❍	❍	❍	❍
I want to adapt my energy use to be at times of lower energy demand.	❍	❍	❍	❍	❍	❍	❍
I intend to adapt my energy use to be at times of lower energy demand.	❍	❍	❍	❍	❍	❍	❍
I expect I will adapt my energy use to be at times of lower energy demand.	❍	❍	❍	❍	❍	❍	❍

Great! For this one, there are a series of statements about the environment. Please indicate, with a tick, how strongly you agree or disagree with each statement. It is only your opinions. There are no right or wrong answers.

	Strongly disagree	Modera-tely disagree	Some-what disagree	Neither disagree nor agree	Some-what agree	Modera-tely agree	Strongly agree
We are approaching the limit of the number of people the earth can support.	❍	❍	❍	❍	❍	❍	❍
Humans have the right to modify the natural environment to suit their needs.	❍	❍	❍	❍	❍	❍	❍
When humans interfere with nature it often produces disastrous consequences.	❍	❍	❍	❍	❍	❍	❍
Human ingenuity will insure that we do NOT make the earth unliveable.	❍	❍	❍	❍	❍	❍	❍
Humans are severely abusing the environment.	❍	❍	❍	❍	❍	❍	❍
The earth has plenty of natural resources if we just learn how to develop them.	❍	❍	❍	❍	❍	❍	❍
Plants and animals have as much right as humans to exist.	❍	❍	❍	❍	❍	❍	❍
The balance of nature is strong enough to cope with the impacts of modern industrial nations.	❍	❍	❍	❍	❍	❍	❍

Despite our special abilities, humans are still subject to the laws of nature.	❍	❍	❍	❍	❍	❍	❍
The so-called "ecological crisis" facing humankind has been greatly exaggerated.	❍	❍	❍	❍	❍	❍	❍
The earth is like a spaceship with very limited room and resources.	❍	❍	❍	❍	❍	❍	❍
Humans were meant to rule over the rest of nature.	❍	❍	❍	❍	❍	❍	❍
The balance of nature is very delicate and easily upset.	❍	❍	❍	❍	❍	❍	❍
Humans will eventually learn enough about how nature works to be able to control it.	❍	❍	❍	❍	❍	❍	❍
If things continue on their present course, we will soon experience a major ecological catastrophe.	❍	❍	❍	❍	❍	❍	❍

Amazing that is the end of the questions and the survey! Thank you for your responses and your input, we really appreciate your views. This research will help us to understand how future technologies can be better designed for people. If you have any questions about the research, please contact xxx@shef.ac.uk. Click next to submit!

Appendix D: Correlation Matrices for TAM2 and Augmented TAM2 variables

Correlations of TAM2 variables in Study 2a (*N* =110)

	Mean	Standard Deviation	Intention to use HEMS	Perceived Usefulness	Perceived Ease of Use	Perceived Voluntariness	Image	Home Relevance	Output Quality	Result Demons-trability
Intention to use HEMS	5.60	1.44								
Perceived Usefulness	5.45	1.33	**.816****							
Perceived Ease of Use	5.33	1.07	**.493****	**.520****						
Perceived Voluntariness	5.25	1.12	-.098	-.042	.088					
Image	2.55	1.25	**.354****	**.356****	.169	**-.265****				
Home Relevance	5.00	1.35	**.743****	**.789****	**.360****	-.154	**.415****			
Output Quality	5.15	1.14	**.482****	**.550****	**.648****	.075	**.240***	**.546****		
Result Demonstrability	5.38	0.91	**.492****	**.487****	**.495****	.129	.104	**.507****	**.537****	
Subjective Norm	4.08	1.40	**.252****	**.295****	.044	-.005	**.451****	**.452****	**.275****	**.289****

**. Correlation is significant at the 0.01 level (2-tailed).

*. Correlation is significant at the 0.05 level (2-tailed).

Correlations for the predictors of the Augmented TAM2 in Study 2a (*N* =110)

	Intention to use HEMS	Perceived Usefulness	Perceived Ease of Use	Home Relevance	Goal Internalisation	Perceived Control	Perceived Competency	Intention to manage energy use	Environmental Concern
Perceived Usefulness	**.780****								
Perceived Ease of Use	**.659****	**.674****							
Home Relevance	**.743****	**.789****	**.360****						
Goal Internalisation	**.279****	**.211***	**.254****	**.366****					
Perceived Control	.152	.118	.081	**.255****	.150				
Perceived Competency	.135	**.240***	**.361****	**.191****	**.413****	.104			
Intention to manage energy use	**.402****	**.397****	**.296****	**.538****	**.568****	**.331****	**.328****		
Environmental Concern)	.153	.185	**.286****	.050	.154	-.081	.212*	.035	
Environmental Citizenship	.146	.096	.064	.012	.155	.073	.133	.132	**.341****

**. Correlation is significant at the 0.01 level (2-tailed).
*. Correlation is significant at the 0.05 level (2-tailed).

.767** **.785**** **.5**

9.4 Appendix E: Informed Questionnaire for Study 2b

Demand Side Management Survey

Electricity Generation and Use

At the moment most of your electricity comes from large power stations in the UK. These power stations burn coal, gas or use nuclear energy to make electricity. This electricity is then sent to your home using cables so that you can use it to power your house.

Power stations are always making electricity. How much electricity is being made needs to match with how much electricity is being used. Making too much electricity is wasteful, but not making enough may mean your lights go out.

Peaks in Electricity Demand

When a lot of people are using electricity at the same time it is called a peak. When this happens the power stations must increase the amount of electricity they are making. This is so that they make enough to meet everyone's needs. In the UK a peak time is usually in the evening at around 17:30 (5:30pm). This is when people get home from work and begin to cook food or turn on televisions. The graph below shows how the amount of electricity being used goes up and down during a normal the day and night in the UK.

Graph 1

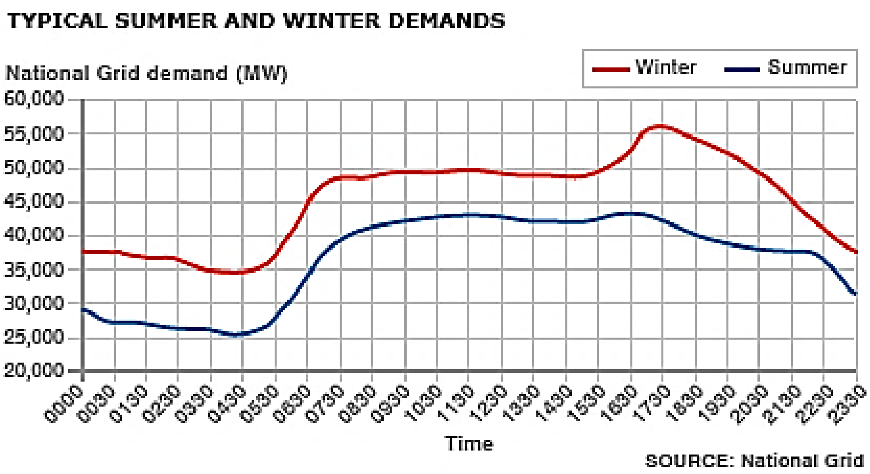


Image retrieved from: http://news.bbc.co.uk/1/hi/sci/tech/7268832.stm

Matching supply with demand

Matching the supply of electricity to the demand for electricity is the job of system operators. They make estimates about how much electricity is going to be needed at a given time of the day and night. These estimates are based on how much is usually needed at that time of day or night. For example, they will estimate there might be more demand at 17:30 in the evening, because there usually is more demand at this time. They then make sure there is enough electricity available at that time.

The system operators have become very good at estimating when electricity use might go up or down. There can still be surprising changes in how much electricity is being used though.

Surprise increases in electricity use are a problem because they mean that the power stations have to work harder to generate the needed electricity. Or more power stations may have to be turned on. This means using more of our oil, coal or gas and extra pollution is made.

Another problem is that predicting electricity use in the future is going to become harder. This is because the way we use electricity is changing.

New technologies in our homes and other buildings will mean bigger and more unpredictable demands for electricity. For example, it is likely that more buildings will start to use electric heating. This will increase demand for electricity, particularly on cold days. Also, more people may use electric cars, which will increase demand for electricity.

Changes in how we make electricity

Bigger and more unpredictable demands for electricity will make demand harder to estimate. On top of this, changes in how we make electricity are going to make the amount of electricity being made, harder to predict.

Wind energy is already being used to supply some of the UK's electricity and more wind farms planned by the year 2030. We also have increasing amounts of renewable sources of electricity, such as solar power.

Wind and solar power stations do not provide a steady supply of electricity like coal, nuclear or gas power stations do. This is because wind, solar and tidal generators all depend on the weather in order to be able to make electricity. For example, wind farms can only make electricity when the wind is blowing.

Because some renewables are dependent on the weather, increasing the UK's reliance on them to provide electricity could increase the chance that the number of people wanting to use electricity ends up higher than the amount of electricity that can be supplied. This is even more likely at times of peak demands. Greater demand for electricity and a less predictable supply of electricity will make matching supply with demand very difficult. It is important that the system operators are still able to match how much electricity is made with how much is wanted.

To make it easier to match the amount of elect ricity being made to the amount of electricity being used, some new technologies will be needed in your house and you might also have to change how and when you use your electricity in your home.

Next page you will find a description of a new technology that will help system operators monitor energy use....Please read through this information carefully, even if you have heard of the technology before.

Technology 1: Real-time Monitoring

In the future, system operators will need to be able to respond faster to changes in the supply and demand levels. This is so that they can keep the balance between the electricity supply and demand.

To help them respond faster to changes the system operators will need to install smart meters in your house. The smart meters will replace your existing electricity meter. These smart meters will provide the system operators with much more accurate and detailed information about your use of electricity.

The information will include how much electricity you are using from one minute to the next. This is called real-time monitoring. It will mean system operators will no longer have to guess about how much electricity you and others are using.

You will also be able to see your own real-time energy usage information via a Home Energy Management Systems (HEMS). Below is a picture of what it could look like.

Image 1: An example of a Home Energy Management System that can display the current energy use in the household and current

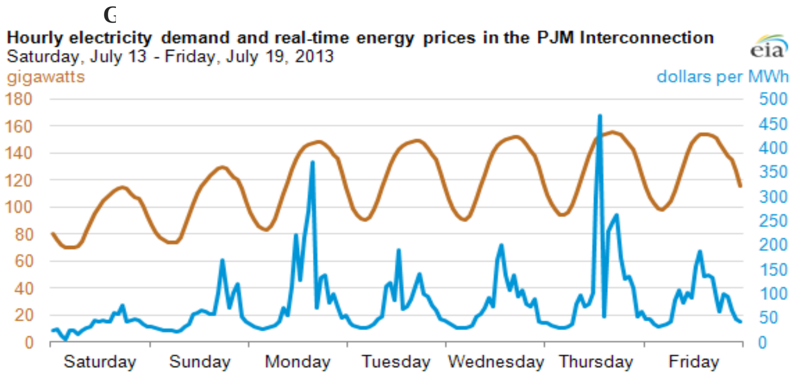
Real-time pricing

The real-time monitoring of electricity use means that system operators can track how much electricity is being used from one minute to the next by a particular neighbourhood. As the amount of electricity being used in a particular neighbourhood changes, the energy providers can change the price of the electricity in response. This is called real-time pricing.

When lots of people are using electricity at the same time the price of the electricity increases. When fewer people are using electricity, the price decreases. The current 'real time' price of electricity in your neighbourhood will be shown on the screen of your Home Energy Management System. This will allow you to keep track of the price across the day and night.

The graph below shows how the price of the electricity (the blue line) changes as the demand of electricity (the brown line) also changes. As you can see, the price of electricity and demand for electricity tend to go up and down together.

It is believed that real time pricing will help system operators to more accurately match supply of electricity with demand for electricity. It is also expected that if the price of electricity increases, that you (and others in your neighbourhood) will look for ways to reduce how much electricity you are using so that you can save money.



(Image retrieved from: https://www.ohmconnect.com/category/energy-market/)

The benefit is that if enough people reduce their electricity use at the same time, then a peak in electricity demand can be avoided.

So, how could real time pricing help you to save money? Some household tasks like using your washing machine use large amounts of electricity. With real time pricing of electricity you could time your use of the washing machine so that it runs when electricity prices are cheaper. For example, you could set your washing machine to start at 3:00 in the morning, when it is unlikely that many other people will be using much electricity and so electricity prices are likely to be cheaper.

Smart meters are already being put in homes in the UK. Real-time pricing has already been introduced in some parts of America. It is currently being discussed by the UK Government and electricity system operators.

Thank you for reading through the information. Based on what you have just read, we would like to know what you think about the Home Energy Management System (HEMS). Please respond to the questions below.

All things considered, use of the Home Energy Management System (HEMS) in my house will be...

	1 (1)	2 (2)	3 (3)	4 (4)	5 (5)	6 (6)	7 (7)	
Good:	❍	❍	❍	❍	❍	❍	❍	Bad
Wise:	❍	❍	❍	❍	❍	❍	❍	Foolish
Favourable:	❍	❍	❍	❍	❍	❍	❍	Unfavourable
Beneficial:	❍	❍	❍	❍	❍	❍	❍	Harmful
Positive:	❍	❍	❍	❍	❍	❍	❍	Negative

Below are a series of statements about YOUR EXPECTATIONS OF the Home Energy Management System (HEMS). Please indicate to what extent you either agree or disagree with the statements.

	Strongly disagree	Modera-tely disagree	Some-what disagree	Neither disagree nor agree	Some-what agree	Modera-tely agree	Strongly agree
Given that I have access to the HEMS, I predict that I would use it.	❍	❍	❍	❍	❍	❍	❍
Assuming I have access to the HEMS, I intend to use it.	❍	❍	❍	❍	❍	❍	❍
Using the HEMS in my house would enable me to control my energy use.	❍	❍	❍	❍	❍	❍	❍
Using the HEMS in my house would improve my energy management.	❍	❍	❍	❍	❍	❍	❍
Using the HEMS in my house would increase my ability to control my energy use.	❍	❍	❍	❍	❍	❍	❍
Using the HEMS would enhance my effectiveness on managing my energy usage.	❍	❍	❍	❍	❍	❍	❍
Using the HEMS would make it easier to manage my energy use.	❍	❍	❍	❍	❍	❍	❍
I would find the HEMS useful in my house.	❍	❍	❍	❍	❍	❍	❍

Learning to operate the HEMS would be easy for me.	❍	❍	❍	❍	❍	❍	❍
I would find it easy to get the HEMS to do what I want to do.	❍	❍	❍	❍	❍	❍	❍
My interaction with the HEMS would be clear and understandable.	❍	❍	❍	❍	❍	❍	❍
I would find the HEMS flexible to interact with.	❍	❍	❍	❍	❍	❍	❍
It would be easy for me to become skilful at using the HEMS.	❍	❍	❍	❍	❍	❍	❍
I would find the HEMS easy to use.	❍	❍	❍	❍	❍	❍	❍

A few more statements about Home Energy Management Systems (HEMS):

	Strongly disagree	Moderately disagree	Somewhat disagree	Neither disagree nor agree	Somewhat agree	Moderately agree	Strongly agree
I feel my use of the HEMS would be voluntary.	❍	❍	❍	❍	❍	❍	❍
My government does not require me to use the HEMS.	❍	❍	❍	❍	❍	❍	❍
Although it might be helpful, using the HEMS is certainly not compulsory for my home.	❍	❍	❍	❍	❍	❍	❍
People in my neighbourhood who use the HEMS have more prestige than those who do not.	❍	❍	❍	❍	❍	❍	❍
People in my neighbourhood who use the HEMS have a high profile.	❍	❍	❍	❍	❍	❍	❍
Having the HEMS is a status symbol in my neighbourhood.	❍	❍	❍	❍	❍	❍	❍
In my home, usage of the HEMS would be important.	❍	❍	❍	❍	❍	❍	❍
In my home, usage of the HEMS is relevant.	❍	❍	❍	❍	❍	❍	❍

The quality of the output I would get from the HEMS sounds like it will be high.	❍	❍	❍	❍	❍	❍	❍
I have no problem with the idea of the HEMS' output.	❍	❍	❍	❍	❍	❍	❍
I would have no difficulty telling others about the results of using the HEMS.	❍	❍	❍	❍	❍	❍	❍
I believe I could communicate to others the consequences of using the HEMS.	❍	❍	❍	❍	❍	❍	❍
The results of using the HEMS are apparent to me.	❍	❍	❍	❍	❍	❍	❍
I would have difficulty explaining why using the HEMS may or may not be beneficial.	❍	❍	❍	❍	❍	❍	❍
People who influence my behaviour would think that I should use the HEMS.	❍	❍	❍	❍	❍	❍	❍
People who are important to me think that I should use the HEMS.	❍	❍	❍	❍	❍	❍	❍

Thank you, you're responses are really helpful! On next is the second of the two technologies...

Once again, please carefully read the information below.

Technology 2: Smart Appliances

Smart appliances have been developed to help with managing household electricity use and to help system operators to accurately balance electricity production with demand.

Examples of smart appliances are smart fridges, freezers, dishwashers, washing machines and air-conditioners. A smart washing machine is shown in the picture on the right. Smart appliances can keep track of the real-time changes in the electricity demand and the price of electricity in your neighbourhood.

For example, if you had a smart washing machine, you could load it up when you wanted and then set the wash to start when the price of electricity in your neighbourhood was low. The smart washing machine would then monitor the real-time price of electricity in your neighbourhood and would begin its washing cycle at a time when the prices were low.

It might not be until late at night or early in the morning that the electricity prices will be low enough for the wash to start. This means you might have to wait longer for your washing to be done. Alternatively, you could set your washing machine to start when you wanted it to, but then you might have to pay a higher cost for the electricity.

Smart Appliances continued:

To make sure that the electricity usage does not go higher than how much is available, sometimes the system operators may need to control how much electricity is being used in houses.

To help with this, the smart household appliances, such as the smart washing machines, dish washers or tumble dryers, could also be remotely switched on and off by the system operators.

This will mean that rather than you setting the smart appliance to track real time prices and start when the electricity price is lowest, you would instead set the appliance to come on a the next available opportunity. This opportunity would be determined by the system operator, who would decide when there was enough spare electricity being produced to meet the demand of your appliance.

Other suggested appliances include fridges and freezers. Fridges and freezers do not have to be on all the time to keep food cold. If electricity demand for an area is too high, the system operator could switch off a large number of the fridges and freezers for a short period of time. Once the demand was lowered, they could then switch them back on.

That's the end of the second technology! We'd now really like to know what you think of it....

Based on what you have just read, we would now like to know what you think about the Smart Appliances. Please respond to the questions below.

All things considered, use of Smart Appliances in my house will be...

	1 (1)	2 (2)	3 (3)	4 (4)	5 (5)	6 (6)	7 (7)	
Good	❍	❍	❍	❍	❍	❍	❍	Bad
Wise	❍	❍	❍	❍	❍	❍	❍	Foolish
Favourable	❍	❍	❍	❍	❍	❍	❍	Unfavourable
Beneficial	❍	❍	❍	❍	❍	❍	❍	Harmful
Positive	❍	❍	❍	❍	❍	❍	❍	Negative

Next we have a series of statements about YOUR EXPECTATIONS OF the Smart Appliances. Please indicate to what extent you either agree or disagree with the statements.

	Strongly disagree	Modera-tely disagree	Some-what disagree	Neither disagree nor agree	Some-what agree	Modera-tely agree	Strongly agree
Given that I have access to Smart Appliances, I predict that I would use them.	❍	❍	❍	❍	❍	❍	❍
Assuming I have access to Smart Appliances, I intend to use them.	❍	❍	❍	❍	❍	❍	❍
Using Smart Appliances in my house would enable me to control my energy use.	❍	❍	❍	❍	❍	❍	❍
Using Smart Appliances in my house would improve my energy management.	❍	❍	❍	❍	❍	❍	❍
Using Smart Appliances in my house would increase my ability to control my energy use.	❍	❍	❍	❍	❍	❍	❍
Using Smart Appliances would enhance my effectiveness on managing my energy usage.	❍	❍	❍	❍	❍	❍	❍
Using Smart Appliances would make it easier to manage my energy use.	❍	❍	❍	❍	❍	❍	❍

I would find Smart Appliances useful in my house.	❍	❍	❍	❍	❍	❍	❍
Learning to operate a Smart appliance would be easy for me.	❍	❍	❍	❍	❍	❍	❍
I would find it easy to get Smart appliances to do what I want to do.	❍	❍	❍	❍	❍	❍	❍
My interaction with Smart appliances would be clear and understandable.	❍	❍	❍	❍	❍	❍	❍
I would find Smart appliances flexible to interact with.	❍	❍	❍	❍	❍	❍	❍
It would be easy for me to become skilful at using Smart appliances.	❍	❍	❍	❍	❍	❍	❍
I would find Smart appliances easy to use.	❍	❍	❍	❍	❍	❍	❍
I feel my use of Smart Appliances would be voluntary.	❍	❍	❍	❍	❍	❍	❍
My government does not require me to use Smart Appliances.	❍	❍	❍	❍	❍	❍	❍
Although it might be helpful, using Smart Appliances is certainly not compulsory for my home.	❍	❍	❍	❍	❍	❍	❍
People in my neighbourhood who use Smart Meters have more prestige than those who do not.	❍	❍	❍	❍	❍	❍	❍

	Strongly disagree	Modera-tely disagree	Some-what disagree	Neither disagree nor agree	Some-what agree	Modera-tely agree	Strongly agree
People in my neighbourhood who use Smart Appliances have a high profile.	❍	❍	❍	❍	❍	❍	❍
Having Smart Appliances is a status symbol in my neighbourhood.	❍	❍	❍	❍	❍	❍	❍
In my home, usage of the Smart Appliances would be important.	❍	❍	❍	❍	❍	❍	❍
The quality of the output I would get from Smart Appliances sounds like it will be high.	❍	❍	❍	❍	❍	❍	❍
I have no problem with the idea of the Smart Appliances' output.	❍	❍	❍	❍	❍	❍	❍
I would have no difficulty telling others about the results of using Smart Appliances.	❍	❍	❍	❍	❍	❍	❍
I believe I could communicate to others the consequences of using Smart Appliances.	❍	❍	❍	❍	❍	❍	❍
The results of using Smart Appliances are apparent to me.	❍	❍	❍	❍	❍	❍	❍
I would have difficulty explaining why using Smart Appliances may or may not be beneficial.	❍	❍	❍	❍	❍	❍	❍
People who influence my behaviour would think that I should use the system.	❍	❍	❍	❍	❍	❍	❍
People who are important to me think that I should use the system.	❍	❍	❍	❍	❍	❍	❍

Thank you! This is really great! You're on to the last bit now where we find out what you think about the environment and technologies.

These questions are about any environmentally related activities you are/have been involved in:

	Yes (1)	No (2)
Are you a member of any group whose main aim is to protect the environment?	❍	❍

In the last 12 months have you....

	Yes (1)	No (2)
...read any newsletters, magazines or other publications written by environmental groups?	❍	❍
...signed a petition in support of protecting the environment?	❍	❍
...given money to an environmental group?	❍	❍
...written a letter or called your member of parliament (MP) or other governmental official to support strong environmental protection?	❍	❍
...boycotted or avoided buying the products of a company because you felt that company was harming the environment?	❍	❍
...voted for a candidate in an election at least in part because he or she was in favour of strong environmental protection?	❍	❍

Great! These next questions are about how you feel about energy usage:

	Strongly disagree	Moderately disagree	Somewhat disagree	Neither disagree nor agree	Somewhat agree	Moderately agree	Strongly agree
I am inspired by the energy reduction we are trying to achieve in the UK.	❍	❍	❍	❍	❍	❍	❍
I am inspired by the energy reduction goals of the UK.	❍	❍	❍	❍	❍	❍	❍
I am enthusiastic about working towards lower energy usage in the UK.	❍	❍	❍	❍	❍	❍	❍
I can influence the way energy is used in my neighbourhood.	❍	❍	❍	❍	❍	❍	❍
I can influence energy decisions in my neighbourhood.	❍	❍	❍	❍	❍	❍	❍
I have the authority to make decisions in my neighbourhood.	❍	❍	❍	❍	❍	❍	❍
I have the skills and abilities to reduce my energy usage well.	❍	❍	❍	❍	❍	❍	❍
I have the competence to manage my energy usage effectively.	❍	❍	❍	❍	❍	❍	❍

I expect I will adapt my energy use to be at times of lower energy demand.	❍	❍	❍	❍	❍	❍	❍
I want to adapt my energy use to be at times of lower energy demand.	❍	❍	❍	❍	❍	❍	❍
I intend to adapt my energy use to be at times of lower energy demand.	❍	❍	❍	❍	❍	❍	❍
I expect I will adapt my energy use to be at times of lower energy demand.	❍	❍	❍	❍	❍	❍	❍

Great! For this one, there are a series of statements about the environment. Please indicate, with a tick, how strongly you agree or disagree with each statement. It is only your opinions. There are no right or wrong answers.

	Strongly disagree	Modera-tely disagree	Some-what disagree	Neither disagree nor agree	Some-what agree	Modera-tely agree	Strongly agree
We are approaching the limit of the number of people the earth can support.	❍	❍	❍	❍	❍	❍	❍
Humans have the right to modify the natural environment to suit their needs.	❍	❍	❍	❍	❍	❍	❍
When humans interfere with nature it often produces disastrous consequences.	❍	❍	❍	❍	❍	❍	❍
Human ingenuity will insure that we do NOT make the earth unliveable.	❍	❍	❍	❍	❍	❍	❍
Humans are severely abusing the environment.	❍	❍	❍	❍	❍	❍	❍
The earth has plenty of natural resources if we just learn how to develop them.	❍	❍	❍	❍	❍	❍	❍
Plants and animals have as much right as humans to exist.	❍	❍	❍	❍	❍	❍	❍
The balance of nature is strong enough to cope with the impacts of modern industrial nations.	❍	❍	❍	❍	❍	❍	❍

Despite our special abilities, humans are still subject to the laws of nature.	❍	❍	❍	❍	❍	❍	❍
The so-called "ecological crisis" facing humankind has been greatly exaggerated.	❍	❍	❍	❍	❍	❍	❍
The earth is like a spaceship with very limited room and resources.	❍	❍	❍	❍	❍	❍	❍
Humans were meant to rule over the rest of nature.	❍	❍	❍	❍	❍	❍	❍
The balance of nature is very delicate and easily upset.	❍	❍	❍	❍	❍	❍	❍
Humans will eventually learn enough about how nature works to be able to control it.	❍	❍	❍	❍	❍	❍	❍
If things continue on their present course, we will soon experience a major ecological catastrophe.	❍	❍	❍	❍	❍	❍	❍

Amazing that is the end of the questions and the survey! Thank you for your responses and your input, we really appreciate your views. This research will help us to understand how future technologies can be better designed for people. If you have any questions about the research, please contact xxx@shef.ac.uk. Click next to submit!

9.5 Appendix F: Expert feedback on Study 2a and Study 2b technology information

We would like your opinions about the quality of the Energy Management information: Please find the point on the scales which best describe your feelings about the information:

#	Question	1	2	3	4	5	Total Responses	Mean
1	Credbile:Dubious	2	5	2	1	0	10	2.20
2	Trustworthy:Untrustworthy	2	5	2	1	0	10	2.20
3	Accurate:Inaccurate	2	4	2	2	0	10	2.40
4	Neutral:Bias	2	3	4	1	0	10	2.40
5	Clear:Unclear	3	6	1	0	0	10	1.80

If you wish, please explain your ratings....

Some elements are inaccurate - grid connected generating systems have to be kept in balance with demand within a tight tolerance otherwise the system begins to experience instabilities that can cause sections to be shutdown. In the worst case this can cause large scale blackouts due to cascading failures.
The passage is well written and clear. However, in my technical understanding some of the information seems inaccurate. Maybe you can correct these. I think it's inaccurate to say 'power stations will produce too much electricity'. In the operation of the electricity network there is always a balance between the supply and the demand of electricity. Otherwise the system will crash. At moments where there is a mismatch, immediately the system operator will take action to rectify it. Also fridges are not a constant, steady demand. The compressors of refrigerators switch on and off quite a number of times within the day. Refrigerators are a potential demand side management appliance. They are not constant electrical loads.
There were some elements that weren't true - power stations are no always on. Several nuclear plants shut down for a range of reasons. It wasn't especially trustworthy or untrustworthy, but the minor errors meant it wasn't completely trustworthy. I felt it was a little biased because it didn't mention carbon emissions, just pollution. Somehow the omission of carbon emissions makes it feel like you are pandering to the petrol lobby by not mentioning climate change which is an important element in this area.
I found that the information presented here is clear and representative of reality. Although the presentation of the information is simplified, it is difficult for me to predict whether a non expert would be able to fully comprehend the information. I think that presenting data from National Grid adds to the credibility of the information. I'm not sure if average Joe is familiar with National Grid or their role. Perhaps that is not important at this stage. Having said that, the information sheet discusses the link between daily consumer activities and the operation of the grid in a fairly straightforward manner. I felt that the presentation of the information has a slight bias towards 'green' energy. It is not necessarily a bad thing but I guess the influence of policy and expectations

of society of a sustainable energy future are difficult to decouple from the technical aspects of grid operation.

It is generally correct (though obviously simplified). There are just a couple of points that I noticed: > fridges and freezers do not consume energy all the time, but have cycles. These cycles are reasonably predictable, though not completely so. I suggest you reword this section or use another example (not that I can think of one...) >Though having excess generation is wasteful, it is not the only negative aspect. It would also cause serious problems within the energy system which would eventually result in black-outs, to prevent damage to generators and other assets.

Please find the point on the scales which best describe your feelings about the Load Shifting information:

#	Question	1	2	3	4	5	Total Responses	Mean
1	Credible:Dubious	1	5	3	0	1	10	2.50
2	Trustworth:Untrustworthy	2	4	3	1	0	10	2.30
3	Accurate:Inaccurate	1	1	6	2	0	10	2.90
4	Neutral:Bias	3	2	2	3	0	10	2.50
5	Clear:Unclear	3	4	3	0	0	10	2.00

If possible please explain your above ratings in the box below:

I always have a problem with the washing machine argument - I don't think the average person would view running a washing machine at 3 in the morning as being desirable even if there is a financial incentive (unload soon after cycle has finished, noise, leakage and fire risk).

This tends to oversimplify the electricity market. Because of the delicate balance in the grid system care must be taken not to reduce demand to the extent that costly shutdowns have to take place, Also there are times when the network needs to be 'quiet' so that generators can economically do plant maintenance. Also new technologies such as EVs and heating electrification could have a significant and and as yet poorly understood impact on 'time of use' pricing.

The equipment to be installed in households are 'smart meters' as opposed to 'computers'. It will replace the conventional electricity meter. The idea of avoiding peak demands are also related to taking dirty fuel power plants (coal) off from the system altogether. Maybe this can be highlighted.

I didn't find this very credible - not because it isn't the right description of what demand side response via time of use tariff proponents say but because of a number of fallacies. People don't have much choice in when they use their power. They want to watch TV before they go to bed. They need to use light when it is dark. The fridge needs to be on etc. There is a lot of information in here that is wrong based on the implicit notions: engineers are not going to come round to put computers in people's houses - people will get to ask for them (in the first instance) and I think they can refuse to have them too. The information being shared with your energy provider is true but implies that someone else is collecting it, which is not true - smart meters are being installed and rolled out by energy companies specifically to reduce home visits.

In this information sheet, the simplification of the information may have led to some technical inaccuracies in contrast to the first sheet (see separate email attachment for details). The slight 'green' energy bias remains. Perhaps there is additional bias in the presentation of the solution of real-time pricing without a view on alternative solutions (whether on the grid or consumer side) to address the same issues. The presentation is still clear.
" engineers are going to use computers in people's houses to monitor how much electricity is being used and at what times". I'm guessing this is based on smart meter roll out? If it is, say that as people (those aware of smart meter rollout) may think that this is additional.
Again, generally correct. > many power stations run most efficiently at maximum power output (because that is the design output). It can be said, however, that smoothing peaks would mean that the lease efficient power stations would not be used as often, therefore increasing overall efficiency.

I feel the information is sufficient to allow the public to judge real-time-pricing in terms of...

#	Question	Yes	No	Unsure	Total Responses	Mean
1	...its usefulness	5	2	3	10	1.80
2	...its purpose	7	2	1	10	1.40
3	...how it works	6	2	2	10	1.60

If you answered "unsure" or "no" to any of the above questions, please could you briefly explain why:

The uesfulness stems from the washing machine case not being convincing. How it works stems from when you will know the price profile - do you know it will be low at 3 in the morning?
The mistrust of the energy companies will lead people to disbelieve how prices are derived and they maybe unhappy sharing detailed usage data.
On usefulness - due to reasons said above. How it works - there is a significant role by upcoming renewable generation which drives real time pricing down. The role of renewable generation is ignored in the information.
As I said above it assumes that people have unrestricted flexibility which they don't. Also is this pricing in relation to supply, so that a peak at night is more expensive than baseline at night, even thought that night peak might be lower than the day time base?
Energy Companies are developing the tech and message in a manner that suits their business model. This is not necessarily a benefit for consumers.

Usefulness: The public might want to know the typical savings that could be made to assess usefulness to them. Purpose: Might it also be linked to availability of generation or local constraints?

I feel real-time-pricing is likely to be implemented in the UK in the next....

#	Answer		Response	%
1	5 years		2	20%
2	10 years		4	40%
3	15 years		3	30%
4	20 years		1	10%
5	25+ years		0	0%
6	Never		0	0%
	Total		10	100%

If possible, please expand on your above answer in the box below:

The costs to the electricity industry vary throughout the day, and when the technology is available to pass those on to the end customer, then a company will take the lead and the others will have to follow.
Much will be dependent on the roll-out of Smart Meters.
There are massive problems with it in terms of people's capacity to respond. It will be rolled out because of the need for big 6 to make profits but people will resist because without some complex arrangements it is unfair.
Given the state of the energy industry and its regulation, I feel it would take some time before it picks up in pace. Prior to such implementation, I believe that a number of discrete trials will be conducted (if not under way already). Afterwards, some time is necessary to understand the outcomes of the trials and implement the mechanism on a national level provided that there's is a good enough benefit vs. cost of implementation vs. customer savings argument. I'm not an expert in electricity markets, but there probably needs to be a number of regulatory framework revisions, consultations, set up time, etc prior to wide scale implementation. The USA trials may be indicative, but I'm not familiar with them.
Based on DECC's smart metering proposals. This will include half hourly pricing registers - whether this is used 'real-time' or day ahead remains to be seen.
I order for RTP to be implemented across all customers, the industry and policy structure will have to change significantly, and customers would have to become more active participants. This may happen, but will not be quick or easy. Industrial or commercial customers may adopt the ideas sooner, and this would still have a significant impact on the demand profile.

To what extent do you feel confident in your responses to the real-time-pricing information?

#	Question	1	2	3	4	5	6	7	8	9	Total Responses	Mean
1	Not at all confident:Completely confident	1	0	0	0	2	2	2	2	1	10	6.20

How knowledgeable do you feel about the topics in the real-time-pricing information?

#	Question	1	2	3	4	5	6	7	8	9	Total Responses	Mean
1	Not at all:Very	0	0	0	2	0	3	3	1	1	10	6.40

Please find the point on the scales which best describe your feelings about the information:

#	Question	1	2	3	4	5	Total Responses	Mean
1	Credible:Dubious	2	4	1	2	0	9	2.33
2	Trustworth:Untrustworthy	3	3	2	1	0	9	2.11
3	Accurate:Inaccurate	1	3	2	3	0	9	2.78
4	Neutral:Bias	3	3	3	0	0	9	2.00
5	Clear:Unclear	3	3	3	0	0	9	2.00

If possible please explain your above ratings in the box below:

The idea of price-control of devices being on or off is fairly logical but giving the ability for generators to decide feels intrusive. Refinement maybe required in providing additional information as to how the electricity has been generated - is it from low-carbon or renewable sources fro instance?
I think its best to introduce a system operator in your description, as its closer to reality. Power stations are private entities who does not see or care on what the electricity demand is. They only operate on instructions by the system operator (who sees the network) who instructs the level of generation from power stations according to market bids.
This information sheet is fairly simple and clear. The only inaccuracies I found is the ability of the power stations to control loads, which is not the case (see separate email attachment). It is good that the different modes of appliance control (through price or remote control) is presented to the consumer. There are additional modes of control, for example appliances responding to locally measured system frequency (e.g. fridges switching off during low system frequency conditions).

"The demand of electricity in your neighbourhood will be monitored by power stations". I would say that this is not true. The system operator will keep track of total demand. The DNOs might monitor demand within a neighbourhood. However, it doesn't take away from the main point (central monitoring).

Generally good. You could consider mentioning that smart appliances can detect when there is not enough generation on the network and switch themselves off, without external control or data being shared.

I feel the information is sufficient to allow the public to judge smart appliances in terms of...

#	Question	Yes	No	Unsure	Total Responses	Mean
1	...their usefulness	7	1	1	9	1.33
2	...their purpose	9	0	0	9	1.00
3	...how they work	8	1	0	9	1.11

If you answered "unsure" or "no" to any of the above questions, please could you briefly explain why:

The role of the smart appliances are clear. However you contradict the statement you made earlier by saying fridges are constant loads.

Demand drivers are not primarily white goods.

usefulness: again many customers might assess this in relation to cost. (or perhaps in terms of 'helping renewables'?)

I feel smart appliances are likely to be implemented in the next....

#	Answer		Response	%
1	5 years		3	33%
2	10 years		3	33%
3	15 years		2	22%
4	20 years		1	11%
5	25+ years		0	0%
6	Never		0	0%
	Total		9	100%

If possible, please expand on your above answer in the box below:

The technology has been around a while and I am sure that pilot areas will be trialled soon if this has not already happened.
Linked to the previous question about pricing - until this becomes a real market driver I'm uncertain people will change.
I think there are are a number of prerequisites prior to implementing smart appliances based DSM: - Market and regulatory framework. - Manufacturer momentum. - Communications infrastructure. - Sufficient consumer adoption. The underlying technologies are readily available, but the value of such implementation I think can only be seen with enough consumer adoption in the right economic environment.
Another aspect to consider is frequency responsive appliances...
Some aspects of this are possible now, and products are on the market. However, there is a long way to go before it is considered widely excepted.

To what extent do you feel confident in your responses to the smart appliance information?

#	Question	1	2	3	4	5	6	7	8	9	Total Responses	Mean
1	Not at all confident:Completely confident	0	0	0	0	3	1	3	2	0	9	6.44

How knowledgeable do you feel about the topics in the smart appliance information?

#	Question	1	2	3	4	5	6	7	8	9	Total Responses	Mean
1	Not at all:Very	0	0	1	0	2	1	2	3	0	9	6.33

Do you have any other general comments or suggestions about the information, in terms of its structure and phrasing, bearing in mind the audience is the general public?

In my opinion, in the information about In-Home Displays (IHD), the fact that customers can see how much they are using in pounds and they are provided with usage graphs, which are more tangible to avarage customers, can play a major part.
I think so... let's talk.

The writing is very clear and should understood easily by the general public. Give attention to the accuracy of some of the information as highlighted.

Do you have any other final comments or suggestions about the technologies themselves?

Read my Master's dissertation and in a couple of years my PhD thesis!
I think it would be useful to introduce the role of renewable generation (Wind etc.) in the future and why demand side services are important to manage the network. This is an untouched area in the information sheets. A section on the unpredictable nature of renewable electricity generation and therefore the importance of managing the demand can be highlighted.
most micro-gen solutions are not cost effective. The message comes across as biased in this respect. The level of demand reduction necessary to achieve the next carbon budget should be clearly communicated.

9.6 Appendix G: TAM2 coefficients Study 2a

Model coefficients for TAM2 (Study 2a)

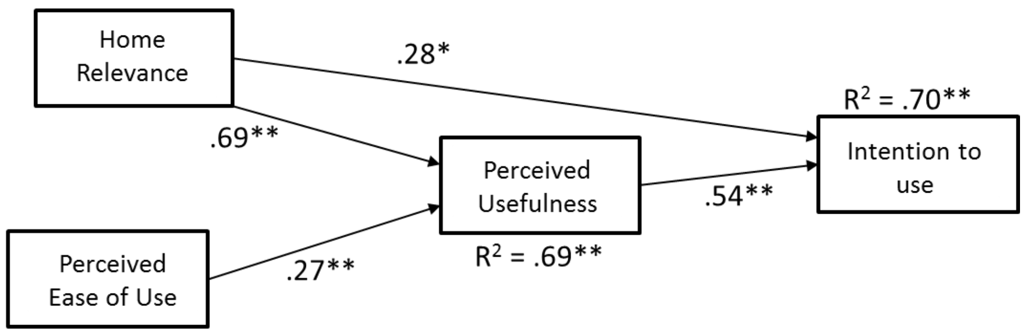
		Consequent						
		Perceived Usefulness (*M*)				Intention to Use the HEMS (*Y*)		
Antecedent (*X*)		Std. Coeff. (β)	*SE*	*p*		Std. Coeff. (β)	*SE*	*p*
Perceived Ease of Use	*a*	.25	.08	**.00**	c'	.12	.08	.13
Voluntariness		.06	.06	.31		-.03	.06	.56
Image		.07	.07	.33		.06	.07	.35
Home Relevance		.71	.08	.00		.28	.10	**.01**
Output Quality		-.01	.08	.93		-.09	.08	.28
Result Demonstrability		.01	.07	.88		.10	.07	.18
Subjective Norm		-.07	.07	.34		-.07	.07	.31
Perceived Usefulness (Mediator)		-	-	-	*b*	.53	.10	**.00**
Constant	i_i	.00	.05	1.00		.00	.05	1.00
		R^2 = .69				R^2 = .71		
		$F(7, 102)$= 32.79 p<.001				$F(8, 101)$= 31.39 p< .001		

Standard Error (SE) estimated from a bias-corrected bootstrap sample of 10,000. Variables with that are significant are emboldened. N=110.

Estimates of the indirect effects (*ab* path) of predictors on intention to use HEMS as mediated by perceived usefulness (*n*-=107).

Antecedent	Std. Coeff. (β)	*SE*	Lower level CI	Upper level CI
Perceived Ease of Use	.13	.09	**.01**	**.37**
Voluntariness	.03	.03	-.02	.12
Image	.03	.04	-.02	.14
Home Relevance	.37	.11	**.18**	**.63**
Output Quality	.00	.06	-.15	.09
Result Demonstrability	.01	.04	-.06	.12
Subjective Norm	-.04	.04	-.13	.03

Confidence intervals (CI) and Standard Error (SE) estimated from a bias-corrected bootstrap sample of 10,000. Lower and Upper CIs without 0 in their range are emboldened.



*Significant at p <.05
**P< .001

Figure 16. Conceptual figure of significant TAM2 variables predicting Intention to Use the HEMS in the climate change condition (Study 2a).

9.7 Appendix H: Correlation Matrices for TAM2 and Augmented TAM2 in Study 2b

Correlations of TAM2 variables in Study 2b (*N* =107)

	Intention to use HEMS	Perceived Usefulness	Perceived Ease of Use	Perceived Voluntariness	Image	Home Relevance	Output Quality	Result Demonst-rability
Perceived Usefulness	**.886****							
Perceived Ease of Use	**.507****	**.604****						
Perceived Voluntariness	**.194***	**.209***	**.246***					
Image	**.361****	**.471****	**.333****	.138				
Home Relevance	**.815****	**.783****	**.450****	**.269****	**.399****			
Output Quality	**.641****	**.679****	**.825****	**.229***	**.385****	**.635****		
Result Demonstrability	**.501****	**.546****	**.602****	.070	**.223***	**.528****	**.710****	
Subjective Norm	**.503****	**.558****	**.457****	.172	**.626****	**.575****	**.520****	**.385****

**. Correlation is significant at the 0.01 level (2-tailed).

*. Correlation is significant at the 0.05 level (2-tailed).

Correlations for the predictors of the Augmented TAM2 in Study 2b (*N* =107)

	Intention to use HEMS	Perceived Usefulness	Perceived Ease of Use	Image	Home Relevance	Goal Internal-isation	Perceived Control	Perceived Competency	Intention to manage energy use	Environmental Concern
Perceived Usefulness	.886**									
Perceived Ease of Use	.507**	.604**								
Image	.361**	.471**	.333**							
Home Relevance	.815**	.783**	.450**	.399**						
Goal Internalisation	.626**	.685**	.443**	.533**	.558**					
Perceived Control	.119	.226**	.293**	.458**	.142	.353**				
Perceived Competency	.068	.149	.262**	-.043**	-.004	.224*	.124**			
Intention to manage energy use	.538**	.537**	.335**	.361**	.562**	.492**	.226*	.162		
Environmental Concern	.263**	.275**	.073	-.082	.204**	.187**	.020	.243*	.245*	
Environmental Citizenship	.188	.187	.171	.112	.082	.154	.226*	.064	.153	.271**

**. Correlation is significant at the 0.01 level (2-tailed).
*. Correlation is significant at the 0.05 level (2-tailed).

9.8 Appendix I: TAM2 coefficients Study 2b

Table *5*. Model coefficients for TAM2 (Study 2b).

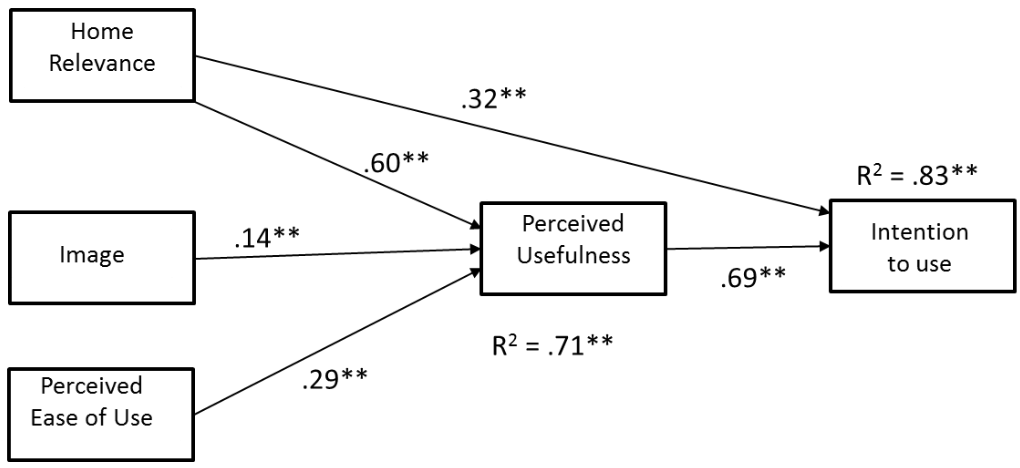
		Consequent						
		Perceived Usefulness (*M*)				Intention to Use the HEMS (*Y*)		
Antecedent (*X*)		Std. Coeff. (β)	*SE*	*p*		Std. Coeff. (β)	*SE*	*p*
Perceived Ease of Use	*a*	.27	.10	.01	*c'*	-.08	.08	.28
Voluntariness		-.04	.06	.47		-.02	.04	.60
Image		.14	.07	.04		-.09	.05	.11
Home Relevance		.60	.08	.00		.30	.08	.00
Output Quality		.01	.12	.92		.13	.09	.16
Result Demonstrability		.03	.08	.67		-.05	.06	.37
Subjective Norm		-.01	.08	.90		-.01	.06	.92
Perceived Usefulness (Mediator)		-	-	-	*b*	.69	.08	.00
Constant	i_1	.00	.05	1.00	i_2	.00	.06	1.00
		R^2 = .71				R^2 = .83		
		$F(7, 99)$= 34.76 p<.001				$F(8, 98)$= 61.19 p< .001		

Standard Error (SE) estimated from a bias-corrected bootstrap sample of 10,000. Variables with that are significant are emboldened. N=107.

Table 6. Estimates of the indirect effects (*ab* path) of predictors on intention to use HEMS as mediated by perceived usefulness (*n*-=107).

Antecedent	Std. Coeff. (β)	*SE*	Lower level CI	Upper level CI
Perceived Ease of Use	.18	.09	**.04**	**.38**
Image	.10	.04	**.04**	**.19**
Home Relevance	.40	.11	**.22**	**.65**
Output Quality	.01	.12	-.26	.22
Result Demonstrability	.03	.09	-.12	.21
Subjective Norm	-.01	.07	-.15	.11

Confidence intervals (CI) and Standard Error (SE) estimated from a bias-corrected bootstrap sample of 10,000. Lower and Upper CIs without 0 in their range are emboldened.



*Significant at p <.05
**P< .001

Figure 17. Conceptual figure of significant TAM2 variables predicting Intention

9.9 Appendix J: Information for Study 3

Load Shifting

Across the UK, at the moment, there is a problem with everyone using their electricity all at the same time. This problem is called peak demand.

A typical example of a peak demand is at 5:30pm (17:30) when a lot of people come home from work and start cooking and watching television. This creates a large increase (a peak) in the amount of electricity being used across the country. Later in the evening, electricity use tends to reduce as people stop cooking and go to bed. The graph below shows a common pattern of peaks in electricity use over time. When peaks in demand happen, power stations have to increase the amount of electricity they are generating to ensure that houses in the UK don't lose power.

Often these peaks in electricity use require so much more electricity to be generated that some of the extra power stations that we have need to be turned on. Once the peak in demand reduces, they are not needed and are turned off again.

Goal Framing Manipulation

Gain Goal Condition

Due to this greater demand and extra generation, the price of the electricity goes up. This means electricity is more expensive when a lot of people are using it.

A scheme called real time pricing will soon mean that the price that you pay for your electricity will change as the level of electricity being used across your neighbourhood changes. For instance, at the times of peak demand in your neighbourhood, you would pay more for your electricity than at other times when there is less demand.

Electricity would be cheaper for you if you, as a householder, could use your electricity at the times when other people in your neighbourhood are not. If you changed the times when you use your electricity, then you would save money.

Normative Goal Condition

Currently, the UK has a legally-binding target to reduce its production of greenhouse gasses by 34% by the 2020.

A scheme called real time information will soon mean that householders will be able to see how much electricity is being used within their neighbourhood. For instance, you would be able to know if there is currently a peak in electricity demand or not within your neighbourhood.

It would be beneficial for the UK if you, as a householder, could use your electricity at the times when other people in your neighbourhood are not. If you changed the times when you use your electricity, you would help to reach the targeted reduction in greenhouse gas emissions.

Everyone

A technology that is designed to help you manage your electricity use is described next...

Home Energy Management System

In order to help you manage your electricity usage and avoid the peaks in demand, you could use a piece of technology called a Home Energy Management System (HEMS). The HEMS can display your household electricity usage on its screen in real-time (i.e. how much you are using right now), as shown in the picture on the right.

It will also be able to display the information about the current level of electricity use in a your neighbourhood. This would tell you whether your neighbourhood's electricity usage is high (peaking) or low.

In principle you could then use this information to help guide your household electricity use in order to avoid the periods of peak demand. For example, you could have a shower a bit later in the evening or cook your food earlier in the evening.

Questions

Automatic

Rather than you looking at the HEMS to see the current electricity use in your neighbourhood, a different option could be to have your household technologies respond to the electricity demand for you.

Some household appliances that use electricity, such as fridges, freezers, dishwashers, washing machines, and heaters, could be made so that they can automatically monitor the changes in electricity demand for themselves. These are called smart appliances.

An example of a smart appliance could be a washing machine. If you had a smart washing machine, you could load it up when you wanted and then set the wash to start when the demand for electricity in your neighbourhood was lower (or not peaking).

The smart washing machine would then keep track of the levels of electricity usage in your neighbourhood and would begin its washing cycle at a time when the electricity demand is lower. Equally, heaters or ovens could be set to come on only when electricity demand is low.

9.10 Appendix K: Correlation Matrices for both conditions of Study 3

Pearson correlation matrices for the 3rd Study Normative Goal Condition variabes.

	Attitude towards load shifting	Attitude towards the HEMS	Intention to Use the HEMS	Perceived Usefulness of the HEMS	Volunt-ariness	Image	Home Relevance	Output Quality	Result Demon-strability	Social Me	Environ-mental Citizen-ship	Environmental Concern	Goal Internalisation	Perceived Control
Attitude towards the HEMS	.507**													
Intention to Use	.379**	.646**												
Perceived Useful	.394**	.678**	.799**											
Voluntariness	-.078	.074	.113	.237**										
Image	.222**	.196**	.248**	.156*	-.159*									
Home Relevance	.447**	.636**	.724**	.696**	.009	.407**								
Output Quality	.291**	.495**	.553**	.564**	.268**	.273**	.537**							
Result Demonstrability	.366**	.519**	.558**	.612**	.290**	.266**	.566**	.671**						
Social Me	.354**	.346**	.364**	.325**	-.028	.504**	.525**	.439**	.419**					
Environmental Citizenship	.189**	.126	.143*	.150*	.064	.095	.191**	.165*	.249**	.274**				
Environmental Concern	.178*	.144*	.192**	.249**	.073	.048	.205**	.175*	.224**	.140*	.421**			
Goal Internalisation	.393**	.513**	.493**	.434**	.023	.371**	.535**	.378**	.436**	.434**	.336**	.317**		
Perceived Control	.136	.116	.131	.019	-.238**	.545**	.234**	.167*	.099	.338**	.030	-.169*	.333**	
Perceived Competency	.149*	.186**	.230**	.250**	.099	.204**	.194**	.384**	.397**	.192**	.187**	.198**	.419**	.181*

*p< .05 ** p< .01

Pearson correlation matrices for the 3rd Study Gain Goal Condition variabes.

	Attitude towards load shifting	Attitude towards the HEMS	Intention to Use the HEMS	Perceived Usefulness of the HEMS	Voluntariness	Image	Home Relevance	Output Quality	Result Demonstrability	Social Me	Environmental Citizenship	Environmental Concern	Goal Internalisation	Perceived Control
Attitude towards the HEMS	.416**													
Intention to Use	.225**	.607**												
Perceived Useful	.292**	.625**	.788**											
Voluntariness	-.001	.031	-.023	.082										
Image	.234**	.151*	.209**	.141*	-.238**									
Home Relevance	.355**	.570**	.692**	.674**	.037	.288**								
Output Quality	.221**	.442**	.458**	.506**	.150*	.207**	.480**							
Result Demonstrability	.256**	.517**	.574**	.562**	.134	.203**	.594**	.649**						
SocialMe	.187**	.332**	.395**	.322**	-.103	.463**	.478**	.371**	.395**					
Environmental Citizenship	.097	.208**	.237**	.214**	.059	.089	.179**	.135	.171*	.297**				
Environmental Concern	.076	.113	.103	.103	.178*	.018	.100	.096	.188**	.086	.285**			
Goal Internalisation	.331**	.223**	.318**	.331**	.007	.311**	.391**	.321**	.361**	.375**	.228**	.327**		
Perceived Control	.275**	.134	.150*	.129	-.117	.542**	.258**	.182**	.125	.353**	.108	-.067	.433**	
Perceived Competency	.185**	.184**	.348**	.302**	.082	.094	.371**	.424**	.435**	.231**	.111	.040	.412**	.234**

*p< .05 ** p< .01

9.11 Appendix I: Pearson's Correlation for TAM2 variables in the Gain and Normative Condition

Pearson Correlations of TAM2 variables from Normative and Gain conditions

	Attitude towards the HEMS	Intention to use HEMS	Perceived Usefulness	Perceived Ease of Use	Perceived Voluntariness	Image	Home Relevance	Output Quality	Result Demonst-rability
Intention to Use the HEMS	.650**								
Perceived Usefulness	.649**	.819**							
Perceived Ease of Use	.404**	.534**	.640**						
Perceived Voluntariness	.067	.058	.177**	.231**					
Image	.179**	.238**	.151**	.033	-.194**				
Home Relevance	.608**	.728**	.683**	.374**	.038	.355**			
Output Quality	.476**	.519**	.545**	.620**	.215**	.243**	.516*		
Result Demonstrability	.527**	.568**	.602**	.509**	.216**	.239**	.584**	.663**	
Subjective Norm	.345**	.382**	.329**	.129**	-.059	.484**	.507**	.411**	.411**

**. Correlation is significant at the 0.01 level (2-tailed).
*. Correlation is significant at the 0.05 level (2-tailed).

9.12 Appendix L: TAM2 Coefficients for Study 3

Gain Goal Condition

Model coefficients for TAM2 in the Gain Goal condition.

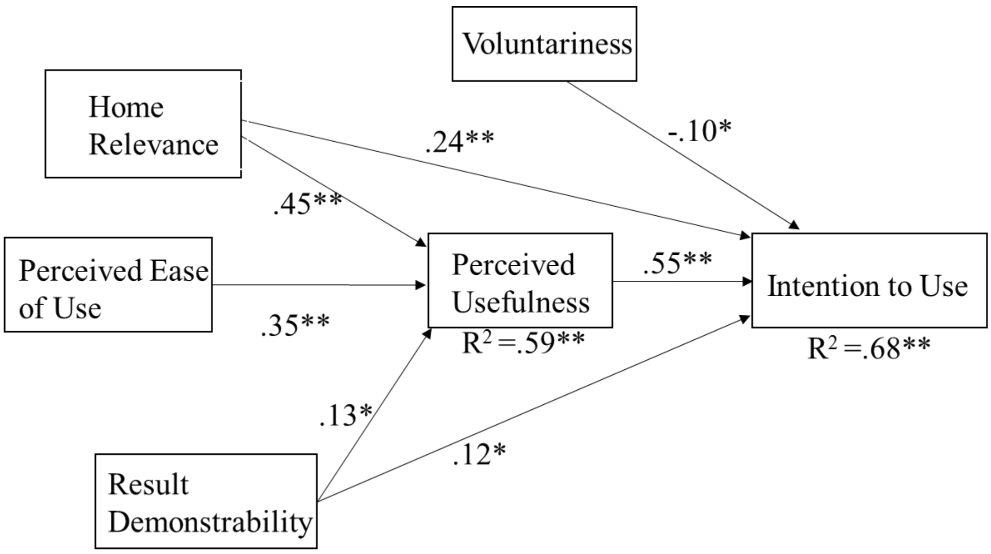
Antecedent (X)		Consequent: *Perceived Usefulness* (M) Std. Coeff.(β)	SE	p		Consequent: *Intention to Use* the HEMS (Y) Std. Coeff. (β)	SE	p
Perceived Ease of Use	a	.36	.06	**.00**	c'	.06	.06	.30
Voluntariness		.00	.05	.98		-.09	.04	**.04**
Image		-.06	.05	.23		.00	.05	.94
Home Relevance		.44	.06	**.00**		.22	.06	**.00**
Output Quality		.00	.07	.98		-.05	.06	.39
Result Demonstrability		.12	.07	.08		.13	.06	**.03**
Subjective Norm		.07	.06	.25		.07	.05	.17
Perceived Usefulness (Mediator)		-	-	-	b	.54	.06	**.00**
Constant	i_1	.00	.04	1.00	i_2	.00	.05	1.00
		$R^2 = .59$				$R^2 = .69$		
		$F(7, 198) = 41.38$ $p<.001$				$F(8, 197) = 54.37$ $p< .001$		

Standard Error (SE) estimated from a bias-corrected bootstrap sample of 10,000.
Variables with $p<.05$ are emboldened. N=206

Estimates of the indirect effects (ab path) of TAM2 predictors on Intention to Use HEMS as mediated by Perceived Usefulness in the Gain Goal condition.

Antecedent	Std. Coeff. (β)	*SE*	Lower level CI	Upper level CI
Perceived Ease of Use	.20	.07	**.07**	**.34**
Voluntariness	.00	.03	-.06	.05
Image	-.03	.03	-.09	.02
Home Relevance	.24	.08	**.10**	**.41**
Output Quality	.00	.05	-.13	.09
Result Demonstrability	.06	.05	-.03	.15
Subjective Norm	.04	.03	-.02	.10

Confidence intervals (CI) and Standard Error (SE) estimated from a bias-corrected bootstrap sample of 10,000. Lower and Upper CIs without 0 in their range are emboldened. N=206.



*Significant at p <.05
**p< .01

Figure 18. TAM2 variables predicting Intention to Use the HEMS in the Gain Goal condition.

Normative Goal Condition

Model coefficients for TAM2 in the Normative Goal condition (*n*=201).

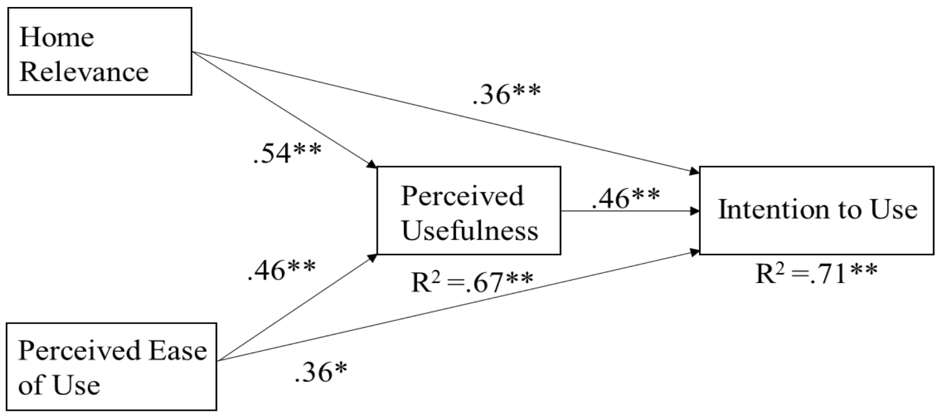
Antecedent (*X*)		Perceived Usefulness (*M*) Std. Coeff.(β)	*SE*	*p*		Intention to Use the HEMS (*Y*) Std. Coeff. (β)	*SE*	*p*
Perceived Ease of Use	*a*	.43	.06	**.00**	*c'*	.15	.06	**.02**
Voluntariness		.07	.04	.15		-.05	.04	.22
Image		-.06	.05	.21		.04	.05	.46
Home Relevance		.56	.05	**.00**		.32	.07	**.00**
Output Quality		-.11	.07	.10		.02	.06	.72
Result Demonstrability		.14	.06	**.02**		.00	.06	.98
Subjective Norm		-.02	.05	.69		-.01	.05	.77
Perceived Usefulness (Mediator)		-	-	-	*b*	.48	.07	**.00**
Constant	i_1	.00	.04	1.00	i_2	.00	.04	1.00
		R^2 = .69				R^2 = .71		
		$F(7, 193)= 62.31$ $p<.001$				$F(8, 192)= 58.62$ $p< .001$		

Standard Error (SE) estimated from a bias-corrected bootstrap sample of 10,000.
Variables with $p<.05$ are emboldened.

Estimates of the indirect effects of TAM2 predictors on Intention to Use HEMS as mediated by Perceived Usefulness in the Normative Goal condition.

Antecedent	Std. Coeff.(β)	*SE*	Lower level CI	Upper level CI
Perceived Ease of Use	.21	.09	**.06**	**.39**
Voluntariness	.03	.03	-.01	.09
Image	-.03	.02	-.09	.01
Home Relevance	.27	.07	**.12**	**.41**
Output Quality	-.05	.04	-.17	.01
Result Demonstrability	.06	.04	**.00**	**.16**
Subjective Norm	-.01	.02	-.06	.04

Confidence intervals (CI) and Standard Error (SE) estimated from a bias-corrected bootstrap sample of 10,000. Lower and Upper CIs without 0 in their range are emboldened. N=201.



*Significant at $p < .05$
**$P < .01$

Figure 19. TAM2 variables predicting Intention to Use the HEMS in the Normative Goal condition.

9.13 Appendix M: The R^2 values for all models

Table of Explained Variance for Perceived Usefulness (PU) and Intention to Use in all models.

Study & Condition	Model	Iteration	Number of Predictors	Variance Explained (PU model in black, Intention to Use in blue)
2a	TAM2	All variables	7 and 8	R^2 = .69 F(7, 102) = 32.79 p <.001 R^2 = .71 F(8, 101) = 31.39 p < .001
		Only sig.	2 and 3	R^2 = .69 F(2, 107) = 117.11 p <.001 R^2 = .70 F(3, 106) = 82.75 p < .001
	Aug. TAM2	All variables	7 and 8	R^2 = .69 F(7, 102) = 32.97 p < .001 R^2 = .72 F(8, 101) = 33.15 p < .001
		Only sig.	3 and 4	R^2 = .69 F(3, 106) = 78.27 p < .001 R^2 = .71 F(4, 105) = 64.22 p < .001
	Moderated Model	All variables	3 and 6	R^2 = .69 F(3, 106) = 78.27 p < .001 R^2 = .73 F(6, 103) = .46.68 p < .001
		Only sig.	2 and 4	R^2 = .69 F(2, 107) = 117.11 p < .001 R^2 = .73 F(5, 104) = .54.71 p < .001
2b	TAM2	All variables	7 and 8	R^2 = .71 F(7, 99) = 34.76 p <.001 R^2 = .83 F(8, 98) = 61.19 p < .001
		Only sig.	3 and 4	R^2 = .76 F(4, 102) = 79.81 p <.001 R^2 = .82 F(5, 101) = 95.01 p < .001
	Aug. TAM2	All variables	8 and 9	R^2 = .77 F(8, 98) = 39.89 p < .001 R^2 = .84 F(9, 97) = 55.97 p < .001
		Only sig.	4 and 5	R^2 = .76 F(4, 102) = 79.81 p < .001 R^2 = .82 F(5, 101) = 95.01 p < .001
	Moderated Model	All variables	3 and 6	R^2 = .71 F(3, 103) = 83.44 p < .001 R^2 = .84 F(6, 10) = 88.53 p < .001
		Only sig.	N/A	All were sig.
3: Gain Goal	TAM2	All variables	7 and 8	R^2 = .59 F(7, 198) = 41.38 p<.001 R^2 = .69 F(8, 197) = 54.37 p< .001
		Only sig.	4 and 5	R^2 = .59 F(4, 201) = 72.21 p<.001 R^2 = .68 F(5, 200) = 72.21 p< .001
	Aug. TAM2	All variables	9 and 10	R^2 = .61 F(9, 196) = 34.35 p < .001 R^2 = .69 F(10, 195) = 43.75 p < .001
		Only sig.	4 and 5	R^2 = .60 F(4, 201) = 74.23 p < .001 R^2 = .68 F(5, 200) = 85.42 p < .001
	Moderated Model	All variables	4 and 7	R^2 = .60 F(4, 201) = 74.23 p < .001 R^2 = .68 F(7 198) = 61.43 p < .001
		Only sig.	N/A	Moderation not sig.
3: Norm-ative Goal	TAM2	All variables	7 and 8	R^2 = .69 F(7, 193) = 62.31 p<.001 R^2 = .71 F(8, 192) = 58.62 p< .001

	Only sig.	2 and 3	$R^2 = .68$ $F(3, 197) = 138.53$ $p<.001$ $R^2 = .71$ $F(4, 196) = 117.49$ $p< .001$
Aug. TAM2	All variables	7 and 8	$R^2 = .69$ $F(7, 193) = 60.41$ $p < .001$ $R^2 = .72$ $F(8, 192) = 60.64$ $p < .001$
	Only sig.	3 and 4	$R^2 = .68$ $F(3, 197) = 139.42$ $p < .001$ $R^2 = .71$ $F(4, 196) = 118.88$ $p < .001$
Moderated Model	All variables	3 and 6	$R^2 = .68$ $F(3, 197) = 139.42$ $p < .001$ $R^2 = .73$ $F(6, 194) = 87.95$ $p < .001$
	Only sig.	N/A	All were sig.