CRANFIELD UNIVERSITY

MARY POTHITOU

Linking energy behaviour, attitude and habits, and social practices with environmental predisposition and knowledge: what are the factors with influence on environmental behaviour?

School of Energy, Environment and Agrifood (SEEA)

MSc by Research

Thesis

Academic Year: 2012-2014

Supervisors:

Professor Sai Gu

Dr. Liz Varga

January 2015

CRANFIELD UNIVERSITY

School of Energy, Environment and Agrifood (SEEA)

MSc by Research

Thesis

Academic Year: 2012-2014

MARY POTHITOU

Linking energy behaviour, attitude and habits, and social practices with environmental predisposition and knowledge: what are the factors with influence on environmental behaviour?

Supervisors:

Professor Sai Gu

Dr. Liz Varga

January 2015

This thesis is submitted in partial fulfillment of the requirements for the degree of Master of Science by Research.

ABSTRACT

This research aims to understand which factors influence environmental behaviour in order to contribute to the existing theory and practice which is focused on individuals' energy consuming behaviour.

As a first step, this thesis reviews existing up-to-date literature related to individual household energy consumption. The *how* and *why* individual behaviour affects the energy use are discussed, together with the principles and perspectives which have so far been considered in order to explain the habitual consuming behaviour. The research gaps, which are revealed from previous studies in terms of the limitations or assumptions of the methodology with respect to altering individuals' energy usage, give insights for a conceptual framework to define a comprehensive approach which attempts to contribute to existing theory. The proposed framework suggests that the individual energy perception gaps are affected by psychological, habitual, structural and cultural variables in a wider-contextual (i.e. national scale), meso-societal and micro-individual spectrum. All these factors need to be considered in order for a variety of combined intervention methods, which are discussed and recommended, to introduce a more effective shift of the conventional energy consuming behaviour, advancing insights for successful energy policies.

Furthermore, this thesis presents and discusses the findings of an empirical study which compares individuals' environmental predisposition and knowledge with their: (a) energy behaviour, attitude and habits; and (b) social practices related to the use and ownership of appliances. This study also attempts to correlate education level and household income with the above variables. The investigation is based on a survey of 68 employees of an educational institution, corresponding to a medium-sized enterprise, which was selected as the first phase of research aiming to compare energy saving behaviour at home and in the workplace. The current study relates only to the domestic aspects of this work attempting to contribute to existing practice by presenting a detailed evaluation of pro-environmental behaviour which can be applied to similar studies while considering different demographics.

In particular, the sample of this study is composed of a relatively highly educated and professional population. The statistical analysis reveals significant correlations

between environmental value and knowledge and elements of individuals' energy attitudes, habits and behaviour. The respondents' predisposition and attitudes is further correlated with social practices associated with domestic appliances. No significant correlations were established to demonstrate that education level may influence environmental predisposition and knowledge, energy saving attitudes, habits and behaviours however, given the nature of the population sample, this is not surprising. An unanticipated outcome from the Principal Component Analysis (PCA) was that household income, and to a lesser extent gender, are associated with energy saving habits and behaviours. On further investigation, household income was found to be correlated with knowledge of greenhouse gas emissions and the number of laptops and electric showers owned per household. Conversely, a relationship between individuals' energy habits and household consumption practices was not indicated by significant correlations.

Keywords: Pro-environmental behaviour, energy behaviour, attitudes, habits, social practices, environmental predisposition, environmental knowledge.

ACKNOWLEDGEMENTS

To begin with, I would like to express my gratitude to my supervisor Professor Sai Gu for making me a stronger person.

I would also like to acknowledge the assistance of my co-supervisor Dr. Liz Varga throughout my time at Cranfield University.

Special thanks to Professor Feargal Brennan, Dr. Athanasios Kolios and Sam Skears for discussions and support during difficult times of my studies; all of their help, in a different way by each of them, is greatly appreciated.

I am grateful for the contribution from Dr. Richard F. Hanna, with statistical analyses of my empirical study.

Finally, I would like to thank especially my family and friends for advice, support and encouragement; I much appreciate your patience and everything you have done for me.

This thesis is dedicated to my Dad (Antonios Pothitos) and my Brother (Manolis Pothitos) – without your support, I would not have managed to accomplish my studies.

TABLE OF CONTENTS

LIST OF FIGURES

LIST OF TABLES

This thesis consists of two published journal papers.

Publication - Journal paper:

Pothitou, M., Kolios, A. J., Varga, L., Gu, S. (2014). A framework for targeting household energy savings through habitual behavioural change. *International Journal of Sustainable Energy*, 1-15. DOI: 10.1080/14786451.2014.936867.

Publication - Journal paper:

Mary Pothitou, Liz Varga, Athanasios J. Kolios, Sai Gu (2015). Linking energy behaviour, attitude and habits with environmental predisposition and knowledge. *International Journal of Sustainable Energy*. DOI: 10.1080/14786451.2015.1032290.

CHAPTER 1: INTRODUCTION

1.0 Background

Energy is a vital commodity which must be carefully managed and maintained in order to meet fundamental needs of human beings. Energy provides an array of necessary services addressing fundamentally the development and wealth of society. The way that commodities are produced, the services which are provided and the growth of economies are dependent upon the energy supply. Lately, the effects of urban and industrial development as well as the population growth increase the energy demand dramatically.

The strong interconnection between human activities and unsustainable energy use has been attributed as the main cause of rapidly increasing energy-related emissions, specifically CO_2 and other greenhouse gases (Clarke et al., 2009). Additionally, the evidence indicates that emissions will increase further due to the current demographic, economic, social, and technological trends. Subsequently, major challenges will be posed to the long-term sustainability of the overall energy system (IPCC, 2014; IEA, 2009; OECD, 2007).

From the late 1980s, household energy consumption has become one of the major research topics in addressing harmful effects to the environment (Poortinga et al., 2003). The household energy consumption, specifically in the UK, is accounted for 29% of the overall energy consumption in 2009 and 26% of overall UK CO_2 emissions. The national target of the UK governmental policy is to cut the greenhouse gas emissions by 34% from 1990 levels by 2020 (Zhang et al., 2012).

Cayla et al. (2011) and Sardianou (2007) hold the view that a household does not consume energy for itself but energy services. The level of household energy use has been shown to vary largely for every single dwelling due to occupants' behaviour (Chen et al., 2012). Therefore, it is the behaviour of individuals who make up the household that leads to the total energy consumption at home and for travelling. The aforementioned range of consumed services is embedded in an extremely complex system which involves technology adoption, microeconomics and behavioural economics, and social as well as psycho-social origin elements (Whitmarsh et al., 2011; Stephenson et al., 2010).

Thereby, it should be emphasized that the technology (e.g. construction building materials and domestic technological equipment) itself can only partly meet the challenge of energy mitigation, namely to reduce the over-consumption of habitual behaviour. Therefore, a radical change in how individuals use energy in their lifestyle is crucial (Gyberg & Palm, 2009). For instance, despite the availability of energy-efficient equipment and sustainable building materials, individuals' consumption tends to outweigh the technical efficiency gains (Steg & Vlek, 2009). Consequently, as Swan & Ugursal (2009) effectively pointed out the key determinants in the overall household consumption are highly dependent upon the "climate, physical dwelling characteristics, appliance and system characteristics, ownership, and occupant behaviour".

Thirty years of research provide a mature insight into behavioural factors which influence household energy efficiency and energy conservation (Cayla et al., 2011; Poortinga et al., 2003; Stephenson et al., 2010), without though these determinants to have been fully exploited yet in the energy field. Energy efficiency is related to specific technologies which are adopted to reduce energy consumption by achieving the utmost provision of services without intervening in the individual's behaviour. Energy conservation, however, lies in changes which individuals make to their own energy usage (Lopes et al., 2012; Whitmarsh et al., 2011). However, Barr et al. (2005) is of the opinion that energy saving behaviour is constituted of consumption oriented behaviour and habitual behaviour which cannot be conceptually divided.

The aim of this literature review is to evaluate an abundance of last decades' available research which proves that the level of energy consumption in houses is heavily dependent upon the individual behaviour. In particular, this review seeks to describe the critical parameters which influence individual energy use mainly in terms of energy conservation referring also briefly to energy efficiency of domestic technical measures. In addition, the literature review sets out potential gaps in previous surveys in understanding household energy consumption and discusses ways in which individual household energy usage can be reduced. Finally, alternative research methods are discussed and a recommendation is proposed in order to develop a new conceptual framework towards a low-energy-consuming lifestyle in the residential sector.

CHAPTER 2: LITERATURE REVIEW

2.0 Habitual behaviour related to energy saving and energy conservation influences

2.1 Technological Efficiency

Technical measures constitute efficient solutions for reducing energy use. However, individuals are confronted with significant decisions in terms of making an initial investment on either the building envelop or energy efficient equipment (e.g. wall and roof insulation, efficient gas boiler or domestic heat pump system, energy-efficient appliances). Poortinga et al. (2003) recognise that technical energy solutions are now more positively received by the public. However, Whitmarsh et al. (2011) oppose this view and based on a representative British survey on 2010 has found that less than half (44%) of the UK population are interested in making additional expenditure on energy-efficient services.

In addition, it should not be ignored that the limitation on individuals to accept or reject technical practices and measures may be related to unrecognised or unidentified reasons and attributes (e.g. individual consciousness, specific preferences) (Yu et al., 2012), motivation (e.g. monetary incentives) (Wada et al., 2012) and contextual factors (e.g. ownership, availability of products and services) (Yu et al., 2011).

Nevertheless an increase in the availability of new energy efficient technologies might eventually bring about an increase in household energy consumption (Kowsari & Zerriffi, 2011; Morton & Griffiths, 2012). This is explained as the rebound effect which on the one hand the increasing use of energy efficient equipment may directly result to increased energy use (Oikonomou et al., 2009; Steg, 2008) and further the predicted energy cost reductions from the adoption of energy efficient techniques can be spent to acquire other products or services which consume energy (Druckman et al., 2011). Consequently, the effectiveness of a technical measure should be determined by the net amount of energy which is saved by the equipment/efficient technology without omitting the amount of energy required to run that equipment (Poortinga et al., 2003). The consumer's awareness of technological effectiveness in accordance with the energy conservation behaviour brings in the benefit of the

efficient domestic equipment such as domestic electrical devices and heating systems. This view is further enhanced by Mills & Schleich (2012) study which revealed a positive correlation between socio-economic factors (e.g. higher income, higher education level, higher electricity prices) and consumers' knowledge about the energy efficiency of the domestic appliances. Econometric analyses of studies related to energy efficiency technology adoption, as for instance Brechling & Smith (1994) and OECD (2011), revealed and suggested a positive correlation between education level and energy-saving activities. In addition, Gadenne et al. (2012) presented studies which support the link between consumers' knowledge of environmental issues and positive environmental behaviours, and further potential of environmental oriented purchasing behaviour.

2.2 Behavioural economics

Financial incentives are commonly applied to influence individual energy use. According to Gadenne et al. (2011) and Whitmarsh et al. (2011) consumers respond positively in changing their energy use when motivated by financial rewards. Economics often use rational choice models in order to provide economic analysis. The rational choice theory is an economic principle which suggests that consumers' behaviour depends on the expected outcome of rational deliberation. The decisions are prudent and logical with high interest on self-concern (Elster, 1986 and Homans, 1961).

Rational choice models are also called Expected Utility, having its roots to Consumer Preference Theory (Darnton, 2008). The four elements that the theory balances are related to 'the consumer's available income, the price of goods, the consumer's preferences, and the assumption of utility maximization' (Jackson, 2005). The latter is assumed to be followed for the most purposes of individuals' preferences in economic models which can be conceived as levels of satisfaction, happiness or personal benefits.

Economics and psychology disciplines have been combined in Behavioural Economics in order for theorists to better identify and explain limitations in the decision making process of people since evidence has shown that individuals' preferences, which are related to the cost gains and benefits of a purchasing

behaviour, are inconstant (Darnton, 2008). The most widely applied principles of Behavioural economics which serve as qualifications to rational choice theory are summarized as follows.

- ***Hyperbolic discounting***

This explains the discount rate which individuals consider while processing in decision making and results from their tendency to offset long-term benefits against short-term rewards. Taking into account that the rates which are applied vary across the timeframe of people's decision process and may be 'hyperbolic' increased, the outcome is that the individuals' preferences are not constant (Wilson & Dowlatabadi, 2007). Wada et al. (2012) interpreted the reason why domestic investments tend to be mainly for appliances. Although energy users evaluate differently the expected future savings through the reduced energy costs in relation to the initial cost across the efficient technology/appliances, most of the surveys conducted confirm that individuals use discount rates in their behavioural consumption which are too high in relation to the available future cost of money in financial markets. Studies have shown that households of lower income have the highest discount rates and are more in favor of purchasing cheaper appliances. The energy efficiency rates of these appliances, in turn, are usually much lower.

- ***Framing***

The individual decisions are influenced from the availability of the choices ('reference frame') and the way these choices are presented to people. Presenting the items in a different order, namely framing the same choice in terms of losses instead of gains can alter a decision made (Talbot et al., 2007; Harford, 2008). For example, a substantial proportion of consumers (40%) have been found to switch to energy suppliers with more expensive tariffs, due to particular elements of these tariffs (such as introductory rate offers or credit card contracts) being marketed as advantageous (Wilson & Waddams Price, 2008).

- ***Inertia***

When individuals face a difficult decision or one that involves many alternative options, they may choose the option which involves the least resistance without altering their behaviour at all. This principle appears to be applied in financial decisions such as investments on efficient technology / measures, or change of energy

supplier (Talbot et al., 2007; Wilson & Dowlatabadi, 2007). This can be exemplified by consumers choosing dual-supply energy tariffs for gas and electricity in return for a discount, which requires less hassle dealing with two separate suppliers (Wilson & Waddams Price, 2008).

Kowsari & Zerriffi (2011) and Seyfang (2010) note that in recent decades, energy intervention strategies are derived more from market-based trends and measures than government initiatives and these strategies have been more beneficial for middle and higher income people. However, public awareness of green energy schemes (e.g. introduction of the Green Energy Supply Certification Scheme, the Green Deal, and Energy Company Obligation (ECO) programmes) regarding the efficiency upgrade of buildings and the provision of green energy tariffs from energy companies remained low based on a survey which showed that 63% of the British public were not aware of the aforementioned schemes and 83% had never used them (Whitmarsh et al., 2011).

The aforementioned schemes and programmes, together with green incentives such as energy companies' time of use tariffs (e.g. Electricity Economy 7), and social enterprises with a charitable foundation (e.g. Energy Saving Trust) related to household energy consumption constitute attempts of the country to sensitize the population towards energy savings, promoting the awareness of energy efficient products and services. This has resulted from the European Union energy tool "Eco-Design Directive (2005/32/EC)" directed at reducing energy consumption of electrical appliances, which was revised in 2009 including all energy-related products (Directive 2009/125/EC) and in 2010 the EU Parliament agreed on a new energy labeling regulation (De Almeida et al., 2011).

It is worth mentioning that among other EU countries (Belgium, Bulgaria, Czech, Denmark, France, Germany, Greece, Hungary, Norway, Portugal and Romania) the highest rates (63%) of energy savings were motivated mainly due to financial reasons (e.g. Hungary-84% and Romania-76%) compared to a low percentage (19.6%) attributed to the purpose of greenhouse gas reduction (Denmark and Greece-45%). In addition, Germany showed the lowest average index of energy efficiency technology adoption and household energy conservation, while Belgium and Greece, on the other hand, showed the highest average index of efficient technology adoption and highest average energy conservation respectively (Mills & Schleich, 2012). Finally, according

to REMODECE (2008), the majority of households (almost 50% in some cases) in the aforementioned European countries have less efficient appliances (older than ten years), apart from Denmark, which is the only country with a percentage of 1-3% of old and inefficient appliances. According to the responses of the European consumers, the two most important criteria for the purchase of a new domestic appliance were related to the price and its electricity consumption followed by the ease of use.

2.3 Societal influences in terms of energy conservation

In recent years, extensive literature has focused on sociological research in terms of energy consumption as a social and collective practice (Kowsari & Zerriffi, 2011). Sociological approaches generally emphasise the relationship between 'inconspicuous' energy use and socio-technical systems holding the view that personal choices both form and are formed by wider social structures (Nye et al., 2010; Hobson, 2003). The term, "socio-technical" refers to a perspective which acknowledges how social and technical aspects of the society as a whole are interrelated (DECC, 2012). This reflects the notion of sociology being derived from the social context which defines the individual needs, attitudes, and expectations in relation with social norms, technologies, infrastructures and institutions.

Sociologists argue that people do not make decisions based on their own energy consumption or the provision of energy resources as the energy services are directly provided from the energy system for individuals to carry out daily activities (Lopes et al., 2012). Nye et al. (2010) (p.702) established that individual consumption emanates from: "wider cultural trends towards consumerism, insatiable wants transformed into 'needs', shifting conventions of normality, increasing individualisation and the use of consumption to define the self, and (un)sustainable sociotechnical systems of provision or supply". As a result, factors in respect to the adoption of an energy consuming behaviour are derived from perspectives which include individual cognitive decisions based on consumption choices or the creation and maintenance of particular social and individual identities.

Many people regard their positive image as hugely important. This in turn encourages individuals to follow the norms of a group to which they intend to belong. For

example a person's level of consumption implies his personal and social identity (Gadenne et al., 2011). Furthermore, Nye et al. (2010) point out that energy is consumed pertaining the modern society as 'consuming' and define the circulation of goods, resulting in sets of practices which are determined by social systems and resources that provide energy (Hobson, 2003). This emphasises that individual choices are restricted based on the availability of technologies supply, individual educational status or the contractors' skills and knowledge. In addition, marketing strategies promote a non-conservation message where individuals are continually exposed to an overload of information (Lopes et al., 2012). The difficulty for individuals to change their consumption patterns is also highlighted since lifestyle and use of material goods construct meanings and identities which account for individual social expectations (social norms), self-expectation (positive or negative outcomes of saving energy) and self-efficacy (perceived effort's effect to save energy) (Thogersen & Gronhoj, 2010) agree with Bandura's social learning theory (Bandura, 1977) of individuals' learning from others' behaviour and outcomes, or perceived behavioural control (Dowd et al., 2012). Gadenne et al. (2011) signifies the importance of social influence towards positive environmental behaviours as well as pointing out that the prerequisite to adopt a pro-environmental behaviour is heavily dependent on strong social norms. This implies that the individual behaviour of domestic energy consumption is influenced by these social norms (emotional, societal and cultural). It is important, however, to mention that the majority of previous models and theories disregard the link between behaviours and socio-technical arrangements (Kowsari & Zerriffi, 2011).

2.4 Social & environmental psychology influences in terms of energy conservation

Social and environmental psychology has developed a comprehensive body of literature based on behavioural energy consumption and conservation. Numerous models and theories have attempted to explain individual energy use, including the theory of cognitive dissonance which predicts that conflicting beliefs (or attitudes) or conflicts between beliefs (or attitudes) and behaviour will yield cognitive dissonance (unpleasant feelings / the sense of discomfort experienced), and people are motivated to reduce this dissonance by either changing their beliefs / attitudes or their behaviour

(Festinger, 1957). Therefore, individuals are provoked to change their behaviour by avoiding dissonance, namely inconsistent beliefs, attitudes and values which influence the way they behave, for example, in respect to energy consumption.

Furthermore, personal efficacy, which is a fundamental construct of the Social Cognitive Theory (Bandura, 1977) and refers to the sense of individual effectiveness or ability to influence a situation, proposes that people are more likely to behave in a certain way if they know that it is possible for them to achieve a goal, task or a challenge. Self-efficacy also appears in the model of Protection Motivation Theory of Rogers (Rogers, 1975) which is based on the responses to fear appeals. Both conceptualisations of Bandura and Rogers are similar as both models present self-efficacy to mediate the influence of motivations on behaviour (Darnton, 2008), namely if individuals deem that a behaviour is impossible to be performed, they will not undertake it although they have been motivated. In respect to individuals' energy behavioural change, the sense of self-efficacy has a major influence on how this challenge is approached by them, namely if people consider that they can perform it successfully or they are convinced for the failure of their performance. An individual with strong self-efficacy feel able to perform well and is likely to face this challenge as achievable rather than something to avoid it. Low self-efficacy can lead people to believe that task such as reduction of their energy use is harder than it actually is. This usually results in poor task planning, as well as increased stress.

An additional group of models which portray behaviour as less intentional suggest that behaviour is driven by habits or emotion as Giddens structuration theory states (Giddens, 1984). It is argued that habit and routine practices related particularly with the energy use play a vital role in human life since it is characterised by repeated behaviour. These energy habits derived from sub-conscious thought where some knowledge is hidden and applied to individuals' daily practices.

According to Hodgson (2007) 'habits are the constitutive material of institutions and the presence of those institutions make accordant habits to be developed and reinforced among the population'. That illustrates the strong influence of energy consuming practices through "structural, cultural, social and institutional forces such as norms, media, technical designs and so on". Therefore, individuals' habits may be

influenced by the established socio-technical forces which will form their energy-consuming options and practices in their everyday way of life (Marechal, 2010). In addition to habitual behaviour, the awareness which influences people in the way they are thinking and talking is referred to as 'discursive consciousness'. This is an expansion of ideas and possibilities which is derived from knowledge, values and experiences (Hobson, 2003).

Bourdieu (1984) accounted for consumption practices from a class-based perceptive, detecting those norms and values are learned and internalised from childhood to adulthood unconsciously. This explains that the habitual energy actions, which are learned from early age, are applied afterwards without people considering the reason why they are used to some particular energy habits.

Giddens's (1984) and Bourdieu theories emphasised that further to understanding energy routines' practices, needs consideration of individuals' mind, hidden knowledge, structure (the rules and resources of society) and agency (the force exerted by the agent) as factors which affect habitual energy use but also identify low or high consuming actions (Gram-Hanssen, 2008). Since individuals have agency, they are also described by Giddens as 'actors', which is in line with Stern's theory (e.g. Gardner and Stern's Principles for Intervening to Change Environmentally Destructive Behaviour, 1996). Based on this reflected view, Darnton concluded that "the audience for an intervention should not be regarded as a passive target but as actors who themselves are at the heart of the change process. It is after all their behaviour which is to change" (Darnton, 2008, p. 18).

Steg & Vlek (2009) pointed out that habitual energy behaviour refers to the approach towards individual decisions in terms of energy use and not to the repetition of the action which refers to the reason why individuals choose to perform their energy habits with a particular way. It is noted that energy habits may involve misperceptions and selective attention, as for example individuals prefer to focus on information that validates their options and on contradictions which do not concur with their behaviour. Consequently, habitual behaviour is expected to be enforced when resultant behaviour of regular actions is satisfactory, although, habitual responses are moderated by mental thoughts. Marechal (2010) underlined the three conditions

which characterise habits: "low degree of involvement, low perceived complexity, low degree of constraint". Actions and practices in terms of daily energy use are likely to be carried out without in-depth conscious thought. Thus, consumers draw on their habits in such situations. With regards to energy consuming decisions which are perceived as low in complexity, a lot of cognitive effort is not required either. As a final point, modern society, which is imposed by time pressure in addition to the overload of information received as part of modern living styles, contributes to insist on the individual energy habits (Marechal, 2010).

2.5 Critical review of existing research

2.5.1 Research limitations on household energy consumption

According to Baker & Rylatt (2008) the majority of the previous surveys on domestic energy, specifically in the UK, have been conducted in small-scale level and are based on small samples of households at local level and large-scale samples focusing at a regional/national level. The large-scale studies produce wider, less detailed results while the small-scale studies involve detailed monitoring but the results are typically restricted to behaviours of a small sample of different household types which might not be representative of the national population.

The aforementioned research methods and theories despite having taken into consideration certain characteristics, have not been tailored enough to meet the demands of social group norms and their motivations (Oikonomou et al., 2009). The limitation of many small scale surveys, potential weaknesses of applied methodologies and insufficient data (e.g. Kowsari & Zerriffi, 2011), the lack of a control groups during the monitoring period without any intervention to verify how effective the applied methods are, as well as the application of a sole intervention method are considered the major reasons for the less effectual results (Morton & Griffiths, 2012). Furthermore, the effectiveness of combining intervention methods is not clearly provided from the current literature of last decade and/or which combination of the methods (e.g. the provision of feedback followed by energy audits, occupants' target settings, community based initiatives and so on) could be proved to be more effective in achieving long-term energy savings (Morton & Griffiths, 2012). Previous surveys revealed that tailored feedback is a commonly successful

intervening method. However some individuals found this practice as an invasion to their private life (Abrahamse et al., 2005).

The 'Hawthorne effect' often attracts disproportionally reduced focus across relevant literature. This identifies what individuals '*wish they were doing, or what they are in principle willing to do and what actual they do*' (Martinsson, 2011). The actual behaviour is influenced from the 'Hawthorne effect', where individuals declare a different behaviour from the behaviour they actually adopt (Whitehead, 2005; Foulds et al., 2013). Also, people may perform unrepresentative, non-typical energy behaviour at the time of their participation in a study which will not carry on after the termination of the intervening period and they will return in the day to day routine practices (Wood & Newborough, 2003).

As a final point, the continuous assessment of the household energy consumption after the end of the intervening period, which enables to determine whether people have adopted and maintained the energy changes in their daily life, is omitted to be included as a prerequisite to appraise the value of the results. The monitoring duration usually varies between researches, however studies which consider to carry on monitoring the consumers' energy consumption enhance the statistical analysis and assessment of survey information as well as the variables of each research (e.g. behaviour, energy consumption, attitudes and demographics) and their correlation towards the evaluation of the project's results (Morton & Griffiths, 2012).

2.5.2 Main barriers of energy habitual behaviour change

Many of the existing studies reviewed have been focused on technological improvements which did not lead to change of lifestyle rather than behavioural-related parameters (Gyberg & Palm, 2009). Therefore, a major question to answer in order to achieve low energy consuming behaviour is how energy household consumption will be influenced by increasing environmental awareness, the green consumer's faith and the "greening of lifestyle". A behaviour framework to reject purchasing/using certain products or actions is not yet developed (Jensen, 2008).

The lack of awareness about economic incentives (e.g. subsidies, governmental initiatives, surcharges) in addition to the lack of capital incentives for energy efficient equipment and ambiguous knowledge about regulatory policies affect individual behavior to avoid change in favor of reduced energy use in the residential sector.

Every day habits are overshadowed by 'symbolic actions' which are considered 'environmental actions' (e.g. using low energy light bulbs or taking shorter showers), since they conserve modest amounts of energy relative to that consumed by living in a large dwelling or travelling frequently or long distances by airplane. This has been shown in the large variation of energy consumption in the studies of residential sector (Jensen, 2008). Emphasizing environmentally friendly technologies and practices based solely on their environmental qualities is not enough. "The challenge is a more reflexive effort where one has to decide whether to give people the right attitudes or make them do the right actions" (Jensen, 2008, p. 360).

In order for individuals to alter their lifestyle towards a more environmental friendly way of living, the knowledge, communication and their engagement have been considered crucial (Mills & Schleich, 2012). This combines supply of accurate information and the promotion of efficient energy consumption in combination with the benefits which will occur to individuals' lives and the environment.

2.5.3 Main gaps research regarding household energy management

Qualitative studies which were conducted based on surveys and interviews (e.g. Abrahamse et al., 2007; Dowd et al., 2012; Fahy & Davies, 2007; Gram-Hanssen, 2008; Gronhoj, 2006; Jensen, 2008; Langevin, 2012; Wood & Newborough, 2003; et al.) revealed consumption patterns and routines in daily occupants' life, which can be summarised by the following:

- Only a small proportion of occupants are generally aware of their annual heating, electricity and water consumption.
- People are confused about the actual cause of global warming and only a limited proportion are able to understand the effect of heating and cooling homes on climate change, which constitutes another important gap in the public's awareness (Steg, 2008).

- Despite the concern of most consumers about environmental issues, this has not been translated into behavioural change (Tsarenko et al., 2013). The initial cost of energy efficient products together with the lack of public funds constitute the major barriers for consumers' uptake and shift in favour of an environmental behaviour (Backlund et al., 2012).
- It is commonly argued that daily routines which are developed and changed along with the availability of different kinds of technologies highly affect household energy consumption. An awareness of household energy use or practices to reduce waste energy from stand-by appliances or heating loss of building envelope and so forth do not necessarily lead to the adoption of a new behaviour because old habits persist.

The aforementioned gaps need to be taken into account in order for an approach to be developed framing conceptually a framework to quantify energy savings potential in the residential sector.

2.6 Development of a framework for household energy savings through habitual behavioural change

2.6.1 Demographics and parameters related to behavioural change

Households need to be described in a more detailed analysis than applied in previous times (Peine & Herrmann, 2012). The review revealed that the energy consumption in the residential sector is highly dependent on demographic parameters and factors. The classification of the factors which affect the patterns of households' energy use can be divided into micro, meso and macro level factors. The macro-level determinants comprise "technological developments, economic growth, social factors, and cultural developments" at the scale of a community or national level. The meso-level determinants are related to the socio-technical context constructed by the interaction of social factors (DECC, 2012). The micro-level factors are at the scale of individual households and include "social-demographic attributes motivational factors, abilities and opportunities" (Abrahamse et al., 2005). However, for household energy consumption behaviour to be considered more accurately further unconsidered personal attributes (e.g. psychological, habitual, structural, or cultural variables),

should be considered as they contribute greatly in explaining the impact of individual behaviour on energy consumption (Yu et al., 2011).

Demographic characteristics and parameters (particularly in relation to private households) need to be categorised into groups in order to be examined more thoroughly and effectively. These can be set out in the following Table (1).

Table 1. Demographics & Parameters to categorise an energy consuming behaviour

Demographics	**References**
Type of family (e.g. nuclear family, single parents)	Silverstone & Hirsch, 1992
Level of income	Zhang et al., 2012
Age of the occupants	Sardianou, 2007; van den Bergh, 2008
Individuals' educational and professional elements (e.g. self-employed or migrant workers)	Sardianou, 2007; van den Bergh, 2008
Parameters	**References**
Tenants or home owners	Sardianou, 2007
Physical attributes of the home (e.g. building type, age of the property, size, building thermal envelope etc.)	Zhang et al., 2012; Slini et al., 2014
Residential physical environment (e.g. land use density, accessibility to public transport)	Yu et al., 2011
Location (e.g. housing area, neighborhood attributes)	Feng et al., 2011
Contextual conditions (e.g. cost-implications, availability of products, energy supplier and price, infrastructure)	Laegran, 2008; Steg & Vlek, 2009
Individual attitudes (e.g. behaviour specific predisposition) & *individual habits and experiences* (e.g. household daily routines, occupants' heating patterns, lifestyle)	Kowsari & Zerriffi, 2011
Heating system of a dwelling - Quantity and type of appliances that households use (e.g. devices'	Slini et al., 2014; Jensen, 2008; Zhang et al., 2012

technical specifications)

Outside temperatures Jensen, 2008; Zhang et al., 2012

Taking into account the demographic parameters as well as attributes which contribute to individual energy behaviour, a comprehensive conceptual approach is proposed (Figure 1). The individual perception related to energy use or misperception from the consumers' perspective in respect to their efficient energy practices vary between individuals as contains informative gaps which influence the habitual energy behaviour. This energy perception is related to individuals' awareness on how to consume consciously or to their predisposition to be aware about the way to conserve energy or even to potentially misperceive energy consumption due to the lack of personal interest and accurate information. This energy perception formulates the energy behaviour which is further influenced by micro, meso, and macro level determinants as well as external factors. The individual energy-consuming behaviour through an interlinked system is formed, enhanced and sustained.

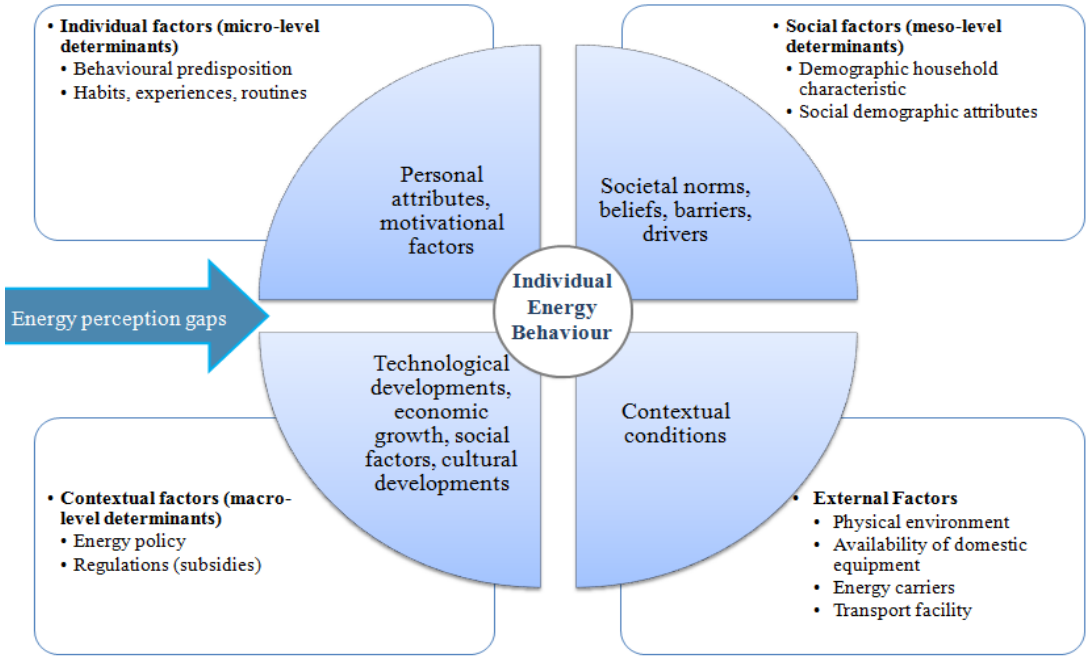

Figure 1. Conceptual Framework on habitual behavioural change

A household consists of one or more individuals who consume according to personal attributes.

• The micro level determinants include these personal attributes such as individual behavioural predisposition, consuming habits, household constitution, and energy routine activities on a household scale. These determinants are recommended from the majority of sources from the review and have also been successfully included in a case study in the context of rural regions in the developing world providing a basis which enable the creation of a more realistic view of household energy use (Kowsari & Zerriffi, 2011). Also, Marechal's (2010, p. 1112) results of an empirical study confirmed that "the presence of strong habits can explain the low effectiveness of traditional measures such as incentives", while "a perturbation of the context, and thus of its related habits, does increase the receptivity towards a given measure". Therefore, there needs to be a thorough consideration from policy-makers into the context of energy habits so that effective measures can be created to reduce domestic energy use.

• The meso level determinants affect energy behaviours in a local / societal scale including norms which influence individuals' energy decisions, societal and class attitudes which are demonstrated through the energy consumption, as well as drivers to perform energy behaviour accordingly. These determinants have been validated from a survey of consumers of three 'environmental friendly' firms which were involved with the trading of green products and services in Australia. The study concluded that "both intrinsic and extrinsic environmental drivers together with social norms and community influence are associated with environmental attitudes; however, related cost barriers may have a negative influence". In addition, environmental norms on environmental actions and prices are influenced by environmental beliefs. The results show that environmental norms on prices are correlated with environmental attitudes (Gadenne et al., 2011, p. 7692).

• Macro level determinants, in a national scale, such as national economic growth and new technologies on energy sector (e.g. Renewable Energy Sources) are affected from regulations and policies, which influence technological development (the infrastructure), energy services (the fuel that is used for energy and the ways that energy is provided), energy economy (the cost of fuels as this is determined by the

market) and social and cultural developments which need to be adjusted in the challenges of new technological energy generation and supply (in a scale of country and continent). Martiskainen (2007) acknowledged the importance of technical and wider societal influences, attributing a high degree of increases in household energy consumption to poor and inefficient construction of houses and to general cultural and technical developments.

• The contextual conditions, in a regional or local scale, comprise the external factors such as physical environment, where the householders are living, the appliances that a household choose to use, the domestic energy provider as well as the transport facility and the occupants' accessibility on public transport which affect the individual energy consumption choices. An empirical analysis on the correlation of residential location and household energy consumption, which was based on the sensitivity of domestic energy use to land use policy by considering multiple self-selection effects, indicated the great role that land-use policy can play in changing patterns of energy consumption by Beijing residents. Besides the technological improvements and economic control tools, the study validates the necessity of self-selection effects such as social, cultural and psychological factors to be considered beyond the observed factors such as socio-demographics, household attributes and so on, in order for policy planners to develop effective measures to save energy (Yu et al., 2012).

This conceptual framework illustrates the interconnection that exists between these factors which need to be taken into consideration in order for the energy behaviour to be assessed. The combination of the aforementioned interconnection together with the reformation of bad energy habits and reinforcement of the habitual energy behaviour in favour of efficient energy practices will lead to a lifestyle of lower energy consumption and consequently, to a greener community.

2.6.2 Recommendations on approaching behavioural change

From the recent literature review, it has been revealed that a research study on the individual behavioural energy consumption will be more effective to be based on a local scale involving representative social groups which are sufficient in order to effectively study and provide insights and comprehensive results. Consequently, the

proposed framework would be effectively applied to local representative communities in order for individuals' energy habits to be identified and potential intervention methods to be set.

With regards to promising measures in delivering energy savings, in a discourse from Gyberg & Palm (2009) information on energy conservation in Swedish households was developed in such a way so to motivate individuals using 'ideological, health and materialistic reasons'. This suggests that the aim of policy tools should be motivational targeting with the purpose of engaging users to consider more their energy consumption than getting more informed about the available technical efficient technologies in the market and energy costs (Gyberg & Palm, 2009; Oikonomou, 2009; Palm, 2010).

However, Langevin et al. (2012) claimed that antecedent information (e.g. pamphlets, internet sites, TV programmes) in general can achieve only modest changes in energy behaviours which are temporarily effective. In line with the aforesaid, Wood & Newborough (2003) stated the adverse effect which results from antecedent information is defined as the 'Fallback effect' or ''the phenomenon in which newness of a change causes people to react, but then that reaction diminishes as the newness wears off''.

A more effective motivational strategy has appeared to be feedback and/or tailored information which is more focused on specific household's characteristics, taking into account personalized information in order to inform householders about energy reduction options (Ellegard & Palm, 2011). Mills & Schleich (2012) and Steg (2008) confirmed that tailored information is likely to increase focus and quality of knowledge of the addressed energy conservation measure, as well as financial and environmental consequences of energy use.

In contrast Ellegard & Palm (2011) and Mills & Schleich (2012) agreed that tailored feedback does not necessarily result in energy conservation behaviours since the environmental effect of individuals' energy use and its indirect impact is difficult to perceive for a householder and react *in favor of*. Three different types and functions of feedback have been outlined by Ellegard & Palm (2011), Robinson (2007) and Wood

& Newborough (2003) which can be applied to household energy consumption. The three types of possible feedback are:

1. The feedback which compares the current with the previous energy use (historic),
2. The feedback which provide comparisons among different households' consumption (comparative) and
3. The feedback which shows the electricity use of domestic appliances (breakdown).

The functions of each of the aforementioned types of feedback in turn are the following:

1. The ***learning function*** which aims to raise the awareness of an occupant about how his/her energy behaviour is linked to the amount of energy that he/she consumes,
2. The ***habit formation*** *which* applies an individual's knowledge into practice to formulate a change of daily habits and
3. The ***internalization*** of behavior which refers to the development of new habits and personal attitudes toward the creation of new behaviour. For example, the same practice can be performed in a more energy efficient way (e.g. using only as much water as required when boiling the kettle) without compromising the comfort and satisfaction of the occupant. If this modified practice is repeated regularly, the occupant will create a new, more energy efficient energy habit and internalize it as a routine behaviour.

Dowd et al. (2012) emphasised that feedback can be further enhanced when is used in conjunction with goal setting strategy thereby the energy savings could be directly assessed by the householders.

2.7 CONCLUSION

The current review is focused on household energy consumption considering that this sector is expected to contribute significantly towards sustainable communities through adoption of lower consuming lifestyles.

This transition should take into account how the regulatory frameworks and mechanisms including constraints in governance processes, strategies for increasing awareness levels, and the financial factor would contribute to energy behaviour efficiency. Towards this goal, after a thorough literature review, it is suggested a comprehensive framework for bringing persistent change in inefficient energy habitual behaviour as well as bringing valuable insights on the question of '*how individual behaviour affects household energy consumption*'.

In order to capture micro-trends, it is suggested that research should commence from local scale and move towards the regional scale. Thus, the proposed framework and potential intervention methods would be more effective first to be applied within a micro-scale (e.g. households) to gain deeper understanding and effectiveness, then to be expanded within a wider scale (e.g. group of people such as wider neighbourhood) and ultimately towards the whole community (e.g. regional scale). This will permit regional policies to be successfully framed as they will capture the virtual needs of the local society. Combining the common characteristics of the different local implementations of the framework would enhance them into a wider pluralistic framework for meeting greenhouse gas emissions and fuel poverty targets as well as domestic targets in respect to household energy reduction.

CHAPTER 3: EMPIRICAL RESEARCH

3.1 Introduction

Kollmuss and Agyeman (2002, p.240) state that "pro-environmental behaviour consciously seeks to minimize the negative impact of one's actions on the natural and built world". Jensen (2002, p.325) further contends that pro-environmental behaviour "only refers to those personal actions that are directly related to environmental improvement, that is to say, direct environmental action, thus pro-environmental behaviour becomes a sub-set of environmental action". These environmental actions can be performed individually or collectively, and may be direct or indirect in their approach to mitigating harm to, and improving, the environment (Jensen, 2002).

The current study holds the view that is important to understand the impact of environmental knowledge and how it influences the development of pro-environmental behaviour which could be useful for policy makers, green marketing, and other parties who are interested in enhancing pro-environmental behaviour.

Researchers have attempted to explain energy behaviour with respect to individuals' environmental education levels and the potential correlation of environmental knowledge with energy attitudes and in turn energy behavioural change (Mills & Schleich, 2012; Gadenne et al., 2011; OECD, 2011). The approach followed by the current study is a response to the lack of previous research investigating how environmental knowledge, attitudes and behaviour are influenced by socio-demographic variables. The methodology employed in this study follows on from this theoretical perspective.

The current research is divided into two phases. The results of Phase 1 are presented in this thesis, and evaluate individuals' energy behaviour at home; Phase 2 will explore individuals' energy behaviour at work, and how this relates to their energy behaviour at home thus comparing the two settings. Much of the literature reviewed approached individuals' environmental behaviour by examining common research areas for a household and an organisation setting such as energy demand, waste and recycling, and modes of commuting (Littleford et al., 2014). The key difference

between an organisational and a household setting regarding control over the performance of behaviour is that in a working environment behaviours are shaped by three main contexts: the 'physical context' which includes automatic control over building systems; the 'social context' which covers users' needs and expectations in societal groups, as well as their social norms; and the 'organisational context' which involves the policy and expectations of the organisation (Littleford et al., 2014). On the other hand, constraints applied in households such as finances, availability of facilities and the sharing of homes may similarly influence individuals' freedom to perform certain energy behaviours; nevertheless, their freedom is not restricted by organizational policy and expectations.

3.2 Aim of the study

A number of studies have considered the relationship of environmental behaviours within different settings and how behaviours in one setting relate to similar ones in a different setting. Researchers (Siero et al., 1996) argue that since the expenditure of a household affects residents while not in the workplace, an energy saving behaviour in a household cannot be generalised to the corresponding behaviour in the workplace. Monetary incentives have been cited as a strong influence on an energy saving behaviour (Barr, 2007), however other researchers have identified numerous influences on environmentally-significant behaviour, including 'situational characteristics, prior awareness and experience of the behaviour, habits and routines, environmental beliefs and values, social and personal norms, and perceptions of behavioural control and self-efficacy' (Littleford et al., 2014; Nisiforou et al., 2012; Barr, 2007). For instance, research on behaviour with respect to waste and recycling reveals that employees who are more active in recycling at home are more likely to perform similar recycling behaviour at work compared to those who are less active in recycling at home. This finding is supported by a sample of hospital workers who reported that they recycled similar items in the workplace to those that they recycled at home (Littleford et al., 2014).

In this context, the wider aim of this study was to give insight into the research question related to individuals' persistence in their energy habits across workplace

and home settings, namely whether they perform the same or different energy practices in the home and in a working environment.

The specific aim of this thesis was to understand how environmental predisposition and knowledge influence pro-environmental behaviours.

In turn, the objectives of this study were to assess:

1. The validity of the generated theoretical framework (Pothitou et al. 2014) using elements of the three dimensions pertaining to environmental predisposition and knowledge, energy habits / attitudes, as well as social practices related to appliance ownership and use; the fourth dimension related to external, conceptual factors was omitted because policy measures are beyond individuals' control.
2. Individuals' environmental predisposition and knowledge in relation to their energy behaviour, attitudes, and habits.
3. Individuals' environmental predisposition and knowledge in relation to their social practices related to the use and ownership of appliances.
4. How socio-demographic variables affect the outcome of these energy demanding practices.

This thesis presents and discusses the findings of an empirical study on individuals' environmental predisposition and knowledge in relation to their energy behaviour, attitudes, and habits. In particular, the empirical study sets out an up-to-date literature review on household energy behaviour and attempts to reveal how environmental knowledge influences individuals' attitudes, habits and behaviour mainly in terms of energy conservation, considering also individuals' interaction with domestic electrical appliances. In addition, the findings are compared with previous studies in order to raise potential areas for further research which will give insights as to individuals' energy consuming behaviour in the residential sector.

3.3 Review of studies on individual energy behaviour

3.3.1 Background

An extensive body of the literature review demonstrates how household energy behaviour and consumption practices are influenced by a wide variety of factors which emphasise how challenging it is to predict how consumption practices are formed, developed and maintained (EEA, 2013). Influences from technology, economy, societal and psychosocial factors have been used to investigate how people use energy and determine the potential for energy conservation through behavioural change (Pothitou et al., 2014; Dowd et al., 2012; Lopes et al., 2012; Gadenne et al., 2011; Kowsari & Zerriffi, 2011; Whitmarsh et al., 2011; Yu et al., 2011; Marechal, 2010; Steg & Vlek, 2009; Darnton, 2008; Hodgson, 2007).

Education is regarded as a key variable which may contribute to a high level of environmental concern for a given individual, and this may in turn influence their environmental behaviour (Vicente-Molina et al., 2013). Environmental concern and behaviour arise due to people's awareness of harmful environmental impacts, which may motivate them towards more environmentally friendly and responsible behaviour (Lozano, 2006). Similarly, highly educated individuals are more likely to obtain increased levels of environmental knowledge, which may lead them to behave in pro-environmental ways (Schlegelmilch et al., 1996). Education provides a medium through which environmental knowledge and skills required to address environmental issues, may be obtained (Vicente-Molina et al., 2013). Despite the direct and significant relationship between education and environmental knowledge, it has not yet been fully established how this relationship affects pro-environmental behaviours (Zsóka et al., 2013).

That pro-environmental behaviour is motivated by values, beliefs and attitudes, is a contention rooted in psychology literature. Behavioural change can result through greater awareness, education or persuasion by others (Clark et al., 2003). Nevertheless, Shove (2003) argues that daily household consumption practices are influenced by social norms and that energy consumption is invisible, being implicated with routines and habits as well as the purchase and use of household appliances. The aforementioned author explores the three conventions of comfort, cleanliness and

convenience as drivers of radical change in domestic energy use. In contrast, the neoclassical economic perspective is based on the premise that people behave rationally and act in their own interests. Accordingly, economists consider that behaviour is influenced by external factors such as price, income, rewards, penalties and regulation (Clark et al., 2003).

Diamantopoulos et al. (2003, p.467) recognise that empirical literature does not attempt to measure, through the research design, how socio-demographic characteristics are related to 'the three theoretical dimensions of the environmental consciousness', i.e. knowledge about green issues, attitudes towards environmental quality, and environmentally sensitive behaviour. This weak link between attitudes and behaviour has also been noted by the aforementioned authors across the literature (e.g. environmental and social marketing). Further to this, a contention in the study is that individuals need to better understand the consequences of their behaviour in order to perform environmentally friendly practices (Diamantopoulos et al., 2003).

Moreover, it has been stated that 'environmental knowledge, values, attitudes, willingness to act and actual behaviours' (Zsóka et al., 2013; Ajzen, 1985) are regarded as the most important determinants related to individuals' environmental awareness, which are further influenced by intentional (that is attributed to situation and/or external causes) and situational (degree of involvement with other people, past experiences, expectations) factors (Vicente-Molina et al., 2013).

To clarify, Sapci & Considine (2014, p.30) state that behaviour is defined as "a joint product of personal attitudinal variables and contextual factors' which include 'interpersonal influences, regulations, interventions, institutional factors, incentives, constraints, knowledge and skills".

Attitude concerns "a person's belief regarding the consequences of undertaking a specific behaviour as a function of the person's valuation of the consequences" (Gadenne et al., 2011, p.7686), and is viewed as "a combination of cognitive and affective responses to objects which is thought to function partly as guide to behaviour" (Axelrod & Lehman, 1993, p.150). Thus, the feelings and beliefs of an individual with respect to an issue or behaviour are assumed to guide their consequential action. This means that individuals' attitude towards the environment

should guide their actions which impact upon the environment. Moreover, the theory of Reasoned Action states that "one's attitude is a reliable predictor of corresponding behaviour when linked with the appropriate action" (Axelrod & Lehman, 1993, p.150).

Despite the received significance from empirical studies, researchers noted an incongruity between attitudes and behaviour, depending on how important an attitude is to the individual. Behaviours vary in the extent to which they can be predicted from attitudes, as some studies reveal that people usually act on issues which are relevant to them and perceived as personally important (Gadenne et al., 2011). Consequently, despite the necessity of a change in attitudes and values as a driver for action, this would not be sufficient to induce pro-environmental behaviour in a predictable way (Zsóka et al., 2013; Marjainé et al., 2011; Arbuthnott, 2009). This is partly because positive environmental attitudes are not necessarily indicative of a high level of knowledge of environmental issues or energy saving (Diamantopoulos et al., 2003). Higher knowledge about environmental issues is assumed to increase people's awareness and concern; however, this does not necessarily lead individuals to change their behaviour (Zsóka et al., 2013; Bamberg & Möser, 2007).

This is further confirmed by several studies, such as Bartiaux (2008) and Oguz et al. (2010), which have not found a significant correlation between education / environmental knowledge and pro-environmental / responsible behaviour.

Other researchers contradict this outcome, contending that people with profound environmental knowledge are more likely to take actions towards the protection of environment and are more likely to exhibit pro-environmental behaviour (Kennedy et al., 2009; Vicente-Molina et al., 2013). Zsóka et al. (2013) enhance this view, purporting that environmental knowledge and pro-environmental behaviour reinforce each other, especially in 'information-seeking' about environmental issues.

According to Bamberg & Moser (2007), pro-environmental behaviour is constrained by the way in which attitudes and intentions are shaped by social norms, which are produced through individuals' interaction with informal education and the media. Social interaction represents a particularly effective means of informal education, through which environmental responsibility may be generated (Chan, 1998) and

environmentally favourable attitudes obtained (Vicente-Molina et al., 2013). Furthermore, Zsóka et al. (2013) argue that social factors explain four-fifths of individuals' environmental awareness and are therefore critical to changing environmental behaviour.

Overall, pro-environmental behaviours are influenced by internal factors (e.g. environmental awareness, attitudes, personal norms, general and environmental values) (Blok et al., 2014) and external factors (e.g. situational characteristics such as social norms and economic constraints) (Mainieri et al., 1997).

3.3.2 Questionnaire survey design

A questionnaire survey was conducted to assess individuals' environmental predisposition and knowledge, establish their attitudes as regards domestic energy, as well as the habitual behaviours of individuals with respect to domestic appliances. The questionnaire, which was constructed by considering a review of relevant methodological literature on survey instruments and question formulation (Langevin et al., 2013; Dowd et al., 2012; Cayla et al., 2011; Marechal, 2010; Hobson, 2003), consists of five sections, covering environmental beliefs, the technical characteristics of the building, the domestic energy equipment, individuals' energy practices and demographics of the population.

The survey questions were developed from a range of theoretical constructs through which aspects of individuals' energy consuming performance could be evaluated, as indicated by respondents themselves. These concepts were related to environmental predisposition (Znang et al., 2012; Kowsari & Zerriffi, 2011; van den Bergh, 2008; Barr et al., 2005), environmental knowledge (Yu et al., 2012; Whitmarsh et al., 2011; Hobson, 2003), energy habits / attitudes (Chen et al., 2012; Wada et al., 2012; Gadenne et al., 2011; Marechal, 2010) as well as social practices related to appliance ownership and use (Thogersen & Gronhoj, 2010; Gram-Hanssen, 2008; Jensen, 2008; Silverstone & Hirsch, 1992).

Table 2. Selected concepts used for the questionnaire

Latent construct	Questionnaire item
Predisposition	How you value the environment in relation to economic considerations.
Knowledge	Greenhouse gas emissions from household energy consumption. Energy saving in the home. Depletion of fossil fuel reserves. The Government's Green Deal.
Energy habits / Attitudes	I have done at least three things to reduce my household's energy consumption. It would save me money to reduce my household's energy consumption. Reducing my household's energy consumption would be inconvenient. I choose to buy energy efficient equipment to reduce my energy consumption. Price is more important than energy efficiency when buying new appliances. I know I need to change my habits and attitudes to reduce household energy consumption. Use low-energy light bulbs? Turn off the lights when you leave a room? Turn off standby appliances? When cold do you put on more clothes/blankets instead of the heating? Fill the washing machine completely for each use? Fill the kettle completely for each use? Fill the dishwasher completely for each use? What temperature do you set your home (or main living room) thermostat to in winter? Do you reduce the temperature on your thermostat or turn your heating off when you are -Absent for half a day; -Absent for one day; -Absent for two days or more; -At night time? In a normal week, when do you and the members of your household have your heating and/or appliances switched on (e.g. thermostat on, kitchen appliances, TV etc.)? –Monday to Sunday (morning / afternoon / evening).
<u>Social Practices</u>: **1) Ownership of appliances**	**Number of '*entertainment appliances*'** (LCD / Plasma TV; Computer (desktop); Computer (laptop/tablet); Games console), **'*utility appliances*'** (Dishwasher; Washing machine; Vacuum cleaner; Tumble dryer; Electric lawn mower; Steam iron; Electric shower; Hair dryer; Air-conditioning unit), **'*kitchen appliances*'** (Microwave; Oven; Toaster; Kettle; Coffee machine; Fridge; Freezer; Fridge-Freezer).

2) Frequency of appliances' use	**How often** (More than once per day / Once per day / 2 - 6 times per week / Once per week / Less than once per week) **do you and the members of your household use the following appliances: '*entertainment appliances*'; '*utility appliances*'; '*kitchen appliances*'.**
3) Duration per use	**How long per use** (1-9 mins / 10-29 mins / 30-59 mins / 1-2 hrs / 2-4 hrs / 5+ hrs) **do you and the members of your household use the following appliances: '*entertainment appliances*'; '*utility appliances*'; '*kitchen appliances*'.**

The questionnaire implemented rating scales with multiple-choice questions. The rating questions applied the five-point Likert scale (Wilkinson & Birmingham, 2003) to capture respondents' views on the ordinal importance of the variables. A survey was appropriate to gather a wide range of data simultaneously (Groat & Wang, 2002; Hunt, 2005) in a cheap, structured and manageable way (Wilkinson & Birmingham, 2003).

3.3.3 Sample of population

The study is focused on the environmental behaviours of a relatively highly educated and professional population in order to demonstrate how knowledge may influence the performance of energy practices. Therefore, the sampling frame consisted of 161 employees who worked in an educational institution during February 2014 (see Table 4 for sample demographics). The household energy consumption survey was distributed via e-mails and hard-copies in order to reduce the likelihood of non-response bias (Creswell, 2014) due to survey media method. The returned completed surveys were 68, equivalent to a 42% response rate.

Although the sample cannot claim to represent national household demographics, the sample intends to represent a medium scale business/educational organisation **(**medium sized enterprise) and assess the social practices performed in a household setting in comparison with those practices in a working environment. This relates to the longer term aim of the research project, set out above, to assess energy saving behaviour in a work setting, compared to that in households. The educational institution studied falls within the definition of a medium sized enterprise (50-249

employees) as defined by the Office for National Statistics and the European Commission (E.C., 2003).

According to Parliament UK (2014), medium sized businesses accounted for 1% of all enterprises in the UK in 2013, 12% of all private sector employment and 15% of total turnover. Although a micro enterprise (0-9 employees) would be more representative of the UK business population since this category comprises 95% of the total number of businesses, 32% of employment and 18% of turnover, a single case study would contain a sample of 9 employees or less and so would not be adequate to support meaningful statistical analysis or capture a variety of demographic characteristics (Rhodes, 2014).

3.3.4 Statistical analysis methods

The statistical analysis was conducted using SPSS (Statistical Package for the Social Sciences) version 21 for Windows. Three different non-parametric statistical tests were applied to the category data generated by the survey. Spearman's rank was used to correlate predisposition and knowledge with energy behaviour, attitudes and habits, while Chi-Square and Fischer's exact tests were conducted to assess the influence of education level and household income on dimensions of pro-environmental behaviour.

The objective was to identify significant associations between environmental predisposition and knowledge and energy behaviour, attitudes and habits, and then attempt to correlate all of the above variables with an indicator of social practices, as measured through the frequency and duration of use, and number of, appliances in each household. Further to this, education level and household income were correlated with the aforementioned variables using Chi-Square and Fischer's exact test.

In the case of Spearman's rank, hypotheses were developed from the literature to support an expected correlation in one direction, and therefore one-tailed significance tests were employed, with 1% and 5% significance thresholds chosen for further investigation and presentation in the findings. For the Chi-Square and Fischer Exact tests, a null hypothesis was assumed, from the starting point that there was no

association between the variables. Response categories were grouped to reduce the number of cells in the correlation tables and increase the chance of valid Chi-Square results (e.g. 20% of cells with minimum expected values). Nevertheless, this criterion was not fulfilled in many cases due to the small sample size, despite experimentation with alternative category groupings. Furthermore, Chi-Square is an approximate test, so Fischer's exact test was used as an alternative, due to its suitability for small samples (Field, 2009).

Principle components analysis (PCA) was used to determine which of the survey variables in the separate correlation tests were most related. Compared to factor analysis, PCA is more appropriate for samples where conclusions should not be extrapolated beyond the sample population itself (Field, 2009). However, in order to meet the minimum criteria for a valid PCA procedure, it was not possible to include many of the variables correlated in the above tests. This is because the correlation matrix produced was not positive definite. If the correlation matrix is not positive definite, this is likely to signify that there is insufficient data to support a PCA for the number of variables included, or that too many variables in the matrix are highly correlated. Consequently, the number of variables was reduced iteratively until a positive definite matrix could be generated (Field, 2009).

Valid PCA outcomes were eventually obtained by selecting nine variables to represent different parameters measured through the survey (see Table 3). It is recognised that the choice of variables is necessarily subjective, but the decision was based upon those which could be instructive in addressing the research aims. Education level and the homeowner / tenant split were excluded from an original selection of eleven variables because the sampling adequacy was less than 0.5. Considering that nine variables were included in the PCA, the study sample of 68 respondents falls within the recommended ratio of sample size to number of variables, i.e. five to ten (Field, 2009; Kass and Tinsley 1979).

It was necessary to ensure that the Kaiser-Meyer-Olkin (KMO) values on the diagonal of the anti-image matrix were at least 0.5. In addition, less than 50% of the residuals in the factor model needed to be greater than 0.05. Components with eigenvalues of greater than 1 were extracted, according to Kaiser's criterion (Field, 2009). The PCA was carried out using both orthogonal and oblique rotation (Varimax and Oblimin

respectively), to allow the outcomes of both methods to be compared. Nevertheless, greater confidence may be placed in extraction using oblique rotation, since it became apparent from other statistical tests that variables included in the PCA were correlated. For Oblimin rotation, a delta (δ) of 0 was chosen (the SPSS default), while the Anderson Rubin method was used to generate the factor scores.

Table 3. Selected variables for principal component analysis

Measurement parameter	'Representative' variable
Knowledge	Knowledge of energy saving in the home
Behaviour	Done at least 3 things to reduce household's energy use
Behaviour	Setting of temperature at home
Habits	Whether the respondents filled the kettle completely for each use
Social practices	Frequency of TV use per week
Social practices	Frequency of oven use per week
Social practices	Frequency of electric shower use per week
Demographics	Gender
Demographics	Household income

CHAPTER 4: RESULTS

4.1 Descriptive statistics

The survey sample obtained consisted mainly of female employees (60%) in comparison with a much lower percentage of males (24%), while the remaining 16% was missing data. Mainieri et al. (1997, p.198) and Olli et al. (2001, p.200) argue that "women have been found to be more pro-environmental in their behaviours". On the other hand, Thogersen & Gronhoj (2010) found that gender influence on household energy consumption is ambiguous and might be direct or indirect (by interaction with other factors). However, women reported that they did slightly more to save electricity at home than men, mainly, but not only, due to household duties more often involving women. Both genders' behaviour with regards to electricity saving is influenced by their willingness to alter social norms, which affects how much electricity they consume. However, only men revealed an additional difference in their energy efficient behaviour with respect to their personal goals, intentions and perceptions of other household members' behaviour. Two hypotheses were developed from these findings: "first, men have a more agentic approach to electricity saving than women and second, that women's electricity saving effort sets a positive example that their spouse tends to follow" (Thogersen & Gronhoj, 2010, p.7740).

Taking into account Communities and Local Government (CLG) data from 2012, which reveals the percentage of homeowner-occupiers in the UK to be 64%, the corresponding proportion in the current study is less for homeowners (53%). The proportion of tenants (29%) in the study sample includes both public and private sector tenants, which is also less than the equivalent figure of 36% in the CLG statistics.

In addition, the most common type of household in the study sample comprises couples with dependent children (29%), followed by couples with children older than 18 years old and couples without children (16% each). This is similar to the UK distribution in that couples with dependent children comprised almost a third of all households in 2013 (Office for National Statistics, 2013).

The education level of the professional group varies mainly between Level 3 ((Level 3 (e.g. AS/A Levels, International Baccalaureate, Advanced and Progression Diploma); Level 5 (e.g. Higher National Certificate, Higher National Diploma); Level 6 (e.g. Bachelor's degree, graduate certificates and diplomas)) and Level 7 (e.g. Master's degree, postgraduate certificates and diplomas) with a slightly higher proportion for Level 4 (18%) (e.g. Certificates of higher education, professional diplomas, certificates and awards) which includes certificates of higher education and professional diplomas, while no one in the sample holds a doctoral degree (Level 8). Compared to National Statistics on educational attainment (NRS, 2014) for the UK in 2013, the study sample has a much larger proportion of people with level 4 and above, with only 3% having no qualification (in 2013, 10% of the population had no qualification in the UK). As the study sample is a group of professionals, it is to be expected that people with no qualifications and entry level (e.g. skills for life, functional skills) are underrepresented.

More than half of the sample was occupied full-time (54%) with a lower percentage of professionals who were part-time employed (21%), and a small percentage of 2% to 3% who were self-employed or retired, but were still involved with activities such as teaching in the educational organisation.

The majority of employees worked in professional occupations (34%) (e.g. teaching and training, financial and statistical services) followed by administrative professions (19%) as well as managerial occupations (12%) (e.g. Manager of business development, Facilities Manager, Manager of finance department, Head of the institution). As with educational attainment, the proportion of professional and managerial occupations is over-represented in the sample (higher and intermediate managerial / professional jobs accounted for 26% of the national population in 2012-13 according to National Readership Survey (NRS) 2014). Meanwhile, manual workers are largely absent in the study sample (they may be included under the skilled trades category). The household income of the study group in turn appears to be relatively high with 30% receiving £20,000 to £39,999 and 28% of the sample having a household income which ranges from £40,000 to £99,999.

Table 4. Survey demographics and descriptive statistics

Demographic variables	Description	Number of respondents (out of 68)	Percentage of respondents (%)
Gender	Male	16	23.5
	Female	41	60.3
	Missing	11	16.2
Homeowner/tenant	Homeowner	36	52.9
	Tenant	20	29.4
	Missing	12	17.6
Type of household	Couple with no children	11	16.2
	Couple with children	20	29.4
	Single parent with children	2	2.9
	House-share	1	1.5
	Single person household	7	10.3
	Other (couple with children older than 18 years old)	11	16.2
	Other (extended family)	2	2.9
	Missing	14	20.6
Highest education level[a]	No qualification	2	2.9
	Level 1	2	2.9
	Level 2	5	7.4
	Level 3	9	13.2
	Level 4	12	17.6
	Level 5	9	13.2
	Level 6	9	13.2
	Level 7	8	11.8
	Missing	12	17.6
Employment status	Employed full-time	37	54.4
	Employed part-time	14	20.6
	Self-employed/casual	2	2.9
	Retired / pension recipient	1	1.5
	Full-time student	1	1.5
	Missing	13	19.1
Occupation	Manager, director, senior official	8	11.8
	Professional occupation	23	33.8
	Technical occupation	2	2.9
	Administrative occupation	13	19.1
	Skilled trades	2	2.9
	Caring, leisure, other service	1	1.5
	Elementary occupation	3	4.4
	Other	4	5.9
	Missing	12	17.6
Household income	Less than £10.000	3	4.4
	£10.000 - £19.999	9	13.2
	£20.000 - £29.999	16	23.5
	£30.000 - £39.999	4	5.9
	£40.000 - £49.999	5	7.4
	£50.000 - £69.999	12	17.6

	£70.000 - £99.999	2	2.9
	Missing	17	25.0

[a]Level 1 (e.g. GCSEs (D-G), Foundation Diploma, BTEC L1); Level 2 (e.g. GCSEs (A*-C), Higher Diploma, BTEC L2); Level 3 (e.g. AS/A Levels, International Baccalaureate, Advanced and Progression Diploma); Level 4 (e.g. Certificates of higher education, professional diplomas, certificates and awards); Level 5 (e.g. Higher National Certificate, Higher National Diploma); Level 6 (e.g. Bachelor's degree, graduate certificates and diplomas); Level 7 (e.g. Master's degree, postgraduate certificates and diplomas).

4.2 Correlation Analysis

4.2.1 Introduction

This section presents the results of different correlation tests applied to the survey data, as described in the section 3.2.4 of Methods, and evaluates the findings against the hypotheses and in the context of the relevant literature. Subsection 4.2.2 evaluates Spearman's rank correlations of predisposition and knowledge versus energy behaviour, attitudes and habits. A Chi-square test is used to assess the extent of relationship between the education level of respondents and their predisposition and knowledge, energy behaviours, attitudes and habits (subsection 4.2.3). In subsection 4.2.4, predisposition and knowledge variables are correlated against indicators of social practices (frequency, duration and number of appliances), using Spearman's rank, Chi-square and Fischer's exact tests. Principal components analysis was then applied to a range of survey variables, and the outcome is presented in subsection 4.3. The final subsection (4.4) discusses the collective implications of the statistical results, and identifies areas for further research.

4.2.2 Predisposition and Knowledge versus Energy Behaviour / Attitude / Habits

The survey analysis generated Spearman's rank correlations of variables with respect to the predisposition of participants in terms of the value of the environment, and the knowledge of energy saving practices in the home versus energy behaviour, attitudes and habits. All those correlations which were significant at a 5% level are presented in Table 5, however, only those with a significance of 1% are discussed below in relation to the hypotheses and supporting literature.

Table 5. Predisposition and Knowledge versus Energy Behaviour / Attitude / Habits

Description of the correlation	Correlation Category	Hypothesis	Supporting Example References	Expected direction of correlation	Spearman's rank results	Significance level (1-tailed)	Number of cases (%)
Valuing the environment versus price is more important than energy efficiency in new appliances	Predisposition versus attitude	***The more people value the environment, the less they care about the price***	Gadenne, et al., 2011.	Negative	-0.4	1%	94
Valuing environment versus use of blankets / clothes instead of heating	Predisposition versus habit (routine)	***The more an individual values the environment, the more likely they are to use blankets / clothes as an alternative to increasing the heating***	Barr, et al., 2005. Barr and Gilg, 2006.	Positive	0.43	1%	85
Knowledge of energy saving in home versus I have done at least 3 things to save energy in the home	Knowledge versus energy behaviour	***The higher the knowledge of energy savings, the more respondents have done at least 3 things to save energy***	Abrahamse, et al., 2007.	Positive	0.53	1%	98.5
Knowledge of energy saving in home versus reducing household energy consumption would be inconvenient	Knowledge versus attitude	***The greater the knowledge, the less the perception of inconvenience in household saving energy***	Barr et al., 2005. Lindén et al., 2006.	Negative	-0.32	1%	95.5
Knowledge of energy saving in home versus choose to buy domestic energy efficient equipment to reduce energy consumption	Knowledge versus energy behaviour	***The greater the knowledge, the more people are likely to purchase energy efficient equipment***	Gadenne, et al., 2011. Mills and Schleich, 2012.	Positive	0.42	1%	95.5
Knowledge of energy saving in	Knowledge versus energy behaviour	***The greater the knowledge,***	Gram-Hanssen, et al., 2007.	Positive	0.34	1%	86.6

home versus use of low-energy light bulbs		***the more people are expected to use low-energy light bulbs***	Gadenne, et al., 2011. Welsch and Kühling, 2010.				
Knowledge of energy saving in home versus turn off standby appliances	Knowledge versus energy habit (routine)	*The greater the knowledge, the more people turn off standby appliances*	Mills and Schleich, 2012.	Positive	0.24	5%	86.5

- Hypothesis 1: The more people value the environment, the less they care about the price

Gadenne et al. (2011) have shown in their study that prices or cost factors influence environmental attitudes and behaviours and that some green consumers with favourable environmental attitudes towards a product or service would spend more to purchase it. This outcome is in line with the finding of a recent UK study (Ozaki, 2011) and a Swiss study which reports that "people with high environmental motivation are less sensitive to price" (Gadenne et al., 2011, p.7691).

- Hypothesis 2: The more an individual values the environment, the more likely they are to use blankets / clothes as an alternative to increasing the heating

Environmental practices are more likely to be implemented by individuals who have a greater sense of environmental issues, which is enhanced by wider social norms and environmental values. Therefore, the behaviour of an individual in daily life is heavily related to these underlying guiding principles (Barr & Gilg, 2006).

The role of environmental values was further investigated by a study based on the Stern et al. (1995) 18-item scale, revealing that the behaviour of an individual could only be predicted when the individual's environmental values combined with their ability to act, is consistently high or low (Barr et al., 2005). In fact, when examining the effect of one of the environmental value constructs, the findings, such as reducing the heating and putting more clothes on, were directly predicted by this effect.

- Hypothesis 3: The higher the knowledge of energy savings, the more respondents have done at least 3 things to save energy

This hypothesis is supported by an empirical study which applied combined intervention methods (e.g. information, goal setting and feedback) in an experimental group of households to examine changes i) in direct and indirect energy use, ii) in energy-related behaviours, and iii) in behavioural antecedents (i.e. knowledge). The study revealed that after five months of intervention methods, the examined households saved 5.1% energy while those in the control group increased their energy use by 0.7%. The energy savings achieved in direct energy use was more significant with no difference in indirect energy use. In addition, energy saving behaviours were adopted by both groups but the study households did so to a higher extent, also exhibiting higher knowledge levels of energy conservation than the control group. Moreover, the experimental group acquired significantly higher knowledge of energy conservation than the control group. More specifically, the participants of the experimental group gave more correct answers on energy saving in comparison to those of the control group (Abrahamse et al., 2007).

- Hypothesis 4: The greater the knowledge, the less the perception of inconvenience in household energy saving

Barr et al. (2005) identified in their empirical study a range of personality and perceptual characteristics related to energy saving behaviour including factors such as price concern, concern for environmental issues, personal comfort and so on. In particular, personal comfort is referred to as a perceived reduction in comfort that might be implied from any energy saving measure.

A study conducted by Lindén et al. (2006) found that the reason for the majority of participants (51%) to lower the heating temperature at night was the comfort experience (e.g. 'it is nicer to sleep in a cool room' (1924) rather than to save energy or money which is expressed by a lower percentage (27%).

A review of the literature revealed a lack of academic research which compares specifically how the experience of comfort in households is correlated with the quality of users' knowledge about energy saving measures.

- Hypothesis 5: The greater the knowledge, the more people are likely to purchase energy efficient equipment

A number of studies reveal a link between knowledge of environmental issues and positive environmental behaviours, finding in particular that consumers with stronger pro-environmental beliefs are more likely to be engaged in environmentally oriented purchasing behaviour (Gadenne et al., 2011).

This view is supported further by Mills & Schleich (2012) who argue that most studies (e.g. Scott, 1997; OECD, 2011) reveal education level and energy efficient technology adoption to be positive correlated. The authors' study in 2010 (Mills & Schleich, 2010) also found that socio-economic factors like higher education levels, higher income, larger households, and higher electricity prices have a positive correlation with participants' knowledge about the energy efficiency label of appliances.

On the other hand, according to Zsóka et al. (2013) there is a current issue whether consumers can rely solely on technological advances on eco-efficiency to achieve energy savings, or whether their contribution in reducing energy use is necessary. The authors contend that environmental education needs to be strengthened to encourage consumer behaviour which is more environmentally responsible.

- Hypothesis 6: The greater the knowledge, the more people are expected to use low-energy light bulbs

The study conducted by Welsch & Kühling (2010) with respect to green behaviour found that consumers without formal education are more likely to commit mistakes in their environmental choices. The correlation between behaviour and education level revealed that better educated people reduce mistakes in the selection of green products and particularly those with university education show that the rate of mistakes is 76% less than a reference group.

Gadenne et al. (2011) further enhance this view arguing that environmental attitudes are significantly associated with environmental behaviour. The results of this study demonstrate that people with positive environmental attitude towards green products and services actually 'do practice what they preach in terms of their environmental

behaviour' (p.7691). More specifically, the consumers with favourable environmental attitudes proceed with the purchase of the green products (e.g. recycled products) and engage in household environmentally friendly activities (e.g. turning off lights when not in use).

However, according to Gram-Hanssen et al. (2007), an important element is the way that people interact with energy label information in the process of purchasing green products. This new information needs to be linked with other types of knowledge (e.g. efficient use of energy appliances, environmental awareness). Consequential changes in practices will be determined by the proper convergence of the perceived information with the quality of knowledge and not from the quantity of the knowledge. Social networks (either real or virtual) are identified as being vital for enhancing this convergence (Goldblatt, 2003).

4.2.3 Education level versus predisposition, knowledge, and energy behaviours / attitudes / habits

As identified above, an individual's predisposition and knowledge may depend on their relative level of education. Therefore, it was deemed necessary to divide the survey sample into two sub-groups according to higher and lower educational attainment, to determine whether, in the first instance, relative education level is correlated with environmental predisposition and knowledge, and then, to establish the extent of correlation between respondents' education and behaviours, attitudes and habits. The education level of the respondents was split into two categories, those with no qualification to Level 4, and those with Levels 5 to 8. As an alternative, the sample was also split into respondents with Levels 6 to 8, and those with lower qualifications. Level 6 corresponds to the completion of a Bachelor's degree, while Level 5 can include foundation degrees, diplomas of higher education and higher national diplomas. Levels 1 to 4 can include diplomas and apprenticeships as well as GCSEs and A-levels (Quality Assurance Agency for Higher Education (QAA), 2008). There is very little evidence to indicate a statistical association between education level and predisposition, knowledge, energy behaviours, attitudes or habits, for when Chi-square and Fischer exact tests were applied, only one significant correlation was obtained, at the 5% level. Therefore, the analysis of the educational split shows that

the correlations between predisposition and knowledge and energy behaviours, attitudes and habits do not seem to be affected by respondents' educational attainment.

The only correlation that was significant at the 5% level revealed that there might be an association between people's educational attainment and whether they change their habits or attitudes to reduce energy consumption. Those with level 5 educational attainment or below may be more likely to change their habits / attitudes to save energy. If knowledge is a product of education, then this would seem to run counter to the expectation that greater knowledge should be associated with energy saving behaviour. Furthermore, as this is the sole significant correlation obtained, only a low level of confidence can be placed in the outcome.

4.2.4 Predisposition and Knowledge versus Social Practices

The next stage of the statistical analysis generated Spearman's rank, Chi-square and Fischer exact test correlations of variables to discover how the predisposition and knowledge of participants might be associated with indicators of social practices, represented by the ownership and use of domestic electrical appliances. These correlation results are presented in Table 6 alongside hypotheses drawn from literature on general trends pertaining to appliance use.

Energy habits and attitudes were also correlated with the ownership and use of domestic electrical appliances using all three of the aforementioned statistical methods. However, the directions of the significant correlations obtained are contradictory and inconsistent, which is likely to reflect the complexity of potential relationships between habits and attitudes, and social practices. Therefore, these particular tests are not considered further in the text, while a table summarizing the correlation results, together with associated hypotheses, can be found in Appendix.

Table 6. Predisposition and Knowledge versus Social Practices

Type of Appliance	Description of the correlation	Hypothesis	Supporting Example References	Expected direction of correlation	Correlation result (Spearman's rank unless stated)	Observations (Chi-square & Fischer's exact test only)	Significance level (1 tailed for Spearman's rank / 2 tailed for Chi-square & Fischer's exact test)	Number of cases (%)
Desktop Computer	Energy saving in the house versus duration of desktop computer use	Null hypothesis	Cabeza, et al., 2014.	N/A	8.7 (Fischer)	A higher number of respondents then expected with good or expert knowledge use a desktop computer for 30m. – 2h.	5%	*49.3*
Laptop	2) Knowledge of energy saving in home versus frequency of laptop use	***Increased knowledge is associated with lower frequency of laptop use***	Gram-Hanssen, 2008.	Negative	2) -0.33		1%	80.6
TV	1) Valuing the environment versus number of TVs 2) Valuing the environment versus duration of TV use	1) ***The more people value the environment, the less number of TVs they have*** 2) Null hypothesis	Cabeza, et al., 2014.	Negative	1) -0.43 2) 5.8 (Fischer)	2) Respondents who assign a higher priority to value the environment, are more likely to watch TV for less time	1) 1% 2) 5%	1) 73.2 2) 76.1
Games Console	Valuing the environment versus number of devices	***The more people value the environment, the less number of devices they have***	Gram-Hanssen, 2008. Cabeza, et al., 2014.	Negative	-0.52		1%	65.7
Vacuum Cleaner	Valuing the environment versus frequency of hovering	***People who value the environment more, hoover less frequently***	N/A	Negative	-0.32		1%	80.6
Steam Iron	Valuing the environment versus frequency of ironing	***The more people value the environment, the less frequently they iron***	N/A	Negative	-0.34		1%	77.6

The authors' literature review of energy use related to household appliances identified a lack of research assessing how appliance use is associated with social, psychosocial and/or socio-economic variables, so as to support the correlation results in Table 6. An exception is Palmer et al. (2013), who present an analysis of the household electricity survey, based on a sample of 250 owner-occupier households in the UK. The level of these homeowners' environmental concern is related to the average number of TVs that they own, which is relevant to the hypothesis in Table 6 correlating the value of the environment with the number of TVs. However, in the aforementioned study there does not seem to be any clear relationship between environmental concern and TV ownership in terms of the average number of units owned. For example, those who were 'very concerned' about the environment, owned 2.1 TVs on average, the same number as those who were 'not very concerned'. A more recent analysis of the same dataset (Palmer et al., 2014) shows that households which were more concerned about climate change actually consumed more electricity overall than those who were less concerned.

Our study revealed that the domestic appliances which are presented as highly correlated with the value of the environment, the knowledge of household greenhouse emissions and energy saving in home, are used extensively. Particularly, with respect to the 'entertainment' appliances, 44% of the respondents own one games console, while 36% did not own a game console. These devices are typically used for 1 to 4 hours, at least 2 to 6 times per week. Also, 82% of participants own one to two TVs, with no respondents indicating they have no TV. The TVs are usually active for 2 to 4 hours with 95% of respondents watching TV at least for once per day. With regard to 'utility' appliances, 92% have one vacuum cleaner using it for 10 to 30 minutes typically, while 56% of the respondents use it at least 2 to 6 times per week. An interesting finding related to a heavy load appliance, which is not included in the correlations, is that a large percentage of the respondents (82%) own one tumble dryer, whereas only 18% did not have one, with 67% using the tumble dryer at least 2 to 6 times per week. This compares to 84% of respondents who use the washing machine at least 2 to 6 times per week respectively.

Reviewing chronological trends with regard to domestic electrical appliances in Great Britain identifies that the ownership of appliances has increased steadily since the

early 1970s. Between 1973 and 1991 the level of ownership for household 'kitchen' appliances such as washing-machines increased by 22% (from 67% to 89%), dishwasher ownership increased by 12% (owned by 1 %, 7% and 13% of households in 1973, 1987 and 1990, respectively), while the increase of freezer ownership is remarkable (from 3% in 1973 to 32% in 1983, rising to 35% and 38% by 1985 and 1991, respectively). By 1992 it was clear that the distribution of ownership levels is associated with the socio-economic group, which ranged from 7% in economically inactive households to 41% among professionals. The review of 'entertainment' appliances indicates an increase of colour-television sets ownership from 49% in 1976 to an average of 1.6 sets per household in 1994 (Mansouri et al., 1996), and 2.4 TVs respectively in 2004 (Energy Saving Trust, 2006). The latter finding is significant due to remote activation, which has become a common feature in modern colour-television sets, resulting in standby losses when the appliance is not in-use.

Standby appliances, in particular electronic equipment such as televisions and set-top boxes, have three basic modes of operation: in use; on standby; or switched off (Firth et al., 2008). Standby is the operation when an appliance is switched off but still consuming energy and it would need to be disconnected from the power supply in order to stop consuming power. Active appliances are those which can be switched on or off without operating in standby mode (e.g. lights and kettles), and when they are not in use their power consumption is zero.

In Great Britain, during early 1990s domestic standby losses accounted for roughly 3.6 TWh yearly (DECADE, 1994). Another analysis of a small household sample (32 participating homes), shows that the average standby demand per household corresponded to an annual average of 277kWh electricity consumption, or 8% of the total electricity use of the residential sector (Mohanty, 2001). A more recent study of the 'Household Electricity Survey' sample of 250 homes (Energy Saving Trust, 2012) found that the standby demand for a household can comprise 9-16% of domestic electricity consumption.

Considering the total annual electricity demand in the UK, Mansouri et al. (1996) presented a breakdown of appliance consumption. The total household electricity

consumption in 1987 was approximately 51.2 TWh which increased to 76.8 TWh in 1994. Growth in the electricity use of appliances may at least in part be explained by increased levels of ownership per household as outlined above. With reference to total UK consumption of the specific appliances for which significant correlations were obtained in Table 6: colour-television sets consumed 5.3 TWh in 1987 compared to 7.2 TWh in 1994; the electricity consumed by irons increased from 1.7 to 2.4 TWh over the same period; while vacuum cleaners used 1.2 TWh in 1994, double their consumption in 1987.

A wider chronological comparison, between 1972 and 2002, showed that the use of electricity by household domestic appliances in the UK doubled from 44TWh to 89TWh per annum. This increase is attributed to the growth of appliances' ownership as well as the fact that these devices consumed electricity even when in standby mode. In particular, the electronic sector, including televisions, video recorders, and external power supply units (digital TV adapters), accounted for 17.3 TWh in 2004 which is equivalent to more than 16% of the total electricity consumed in the residential sector. Televisions contributed most to the total consumption from domestic electronic appliances in 2004 (around 40%), while external power supply units used 18% of the equivalent total in 2000 (Energy Saving Trust, 2006).

In the future, consumer electronics in UK households are predicted to account for 45% of the residential electricity consumption by 2020, due to entertainment equipment, computers and gadgets (Sadorsky, 2012), reaching 49.6TWh. By then, domestic televisions are estimated to consume more (19.3TWh per annum) than the total electricity used by UK consumer electronics in 2004, equivalent to 18TWh (Crosbie, 2008). A recent study by Coleman et al. (2012) which is based on fourteen households further enhances this outcome, arguing that desktop computers together with televisions are the most significant power consuming devices, mostly in the active mode.

In Europe electricity consumption from home appliances which in 1973 accounted for roughly half of the residential electricity use in the group of eleven IEA countries (IEA-11) increased to 58% by 1998. Domestic electrical appliances were responsible for roughly two-thirds of the doubling of European electricity demand between 1973 and 1998. Kitchen appliances such as refrigerators and clothes washing machines

mainly impacted upon the growth of appliance electricity consumption in the early 1980s, while more recent growth in electricity use is due to home electronics and kitchen gadgets (Cabeza et al., 2014).

A case study (Firth et al., 2008) monitoring appliances' electrical consumption in a UK domestic building, shows that electricity use from standby devices grew by 10.2% from the first to the second year of monitoring, while active appliances consumed 4.7% more electricity. However, there is much variability across households, both in terms of appliance ownership and patterns of use. For example, Shove & Hand (2003) argue that the growth of microwave ovens has been attributed to convenience, fashion, and novelty rather than energy efficiency.

4.3 Principal Component Analysis

As already described in the section 3.2.4 of Methods, a principal components analysis (PCA) was applied to nine variables using oblique (Oblimin) rotation based on the assumption that underlying components are related to each other since they represent the same sample of respondents. The sampling adequacy for the PCA test was just above the minimum acceptable Kaiser-Meyer-Olkin (KMO) value of 0.5 (Field, 2009). This reflects the relatively small sample size of the survey. Five components were extracted using Kaiser's criterion of a minimum eigenvalue of 1, so that together, the extracted components account for 78.5% of the variance for both rotation methods applied (Table 7).

Table 7: Initial eigenvalues and variances explained by extracted components

Component	Initial Eigenvalues			Extraction Sums of Squared Loadings		
	Eigenvalue	*% of variance*	*Cumulative variance (%)*	*Eigenvalue*	*% of variance*	*Cumulative variance (%)*
1	2.0	22.4	22.4	2.0	22.4	22.4
2	1.5	16.9	39.3	1.5	16.9	39.3

3	1.3	14.8	54.0	1.3	14.8	54.0
4	1.2	12.9	67.0	1.2	12.9	67.0
5	1.0	11.6	78.5	1.0	11.6	78.5
6	0.7	7.5	86.1			
7	0.5	6.0	92.1			
8	0.5	5.0	97.1			
9	0.3	2.9	100.0			

Tables 8 and 9 present the factor loadings, i.e. correlations between the variables and components, within the pattern and structure matrices generated by oblique rotation. The pattern matrix allows an evaluation of how each variable contributes to a component, while the relationship between components is revealed by the structure matrix. All factor loadings achieve the minimum level of 0.3 required to be considered statistically significant (Field, 2009). Nevertheless, in both tables absolute values above 0.722 are indicated, as according to Stevens (2002), this is a more appropriate criterion for sample sizes of 50, similar to the survey sample collected in this study.

The clusters of factor loadings suggest that the five components represent respectively: 1. Knowledge and energy saving behaviour; 2. Frequency of appliance use; 3.Household income and frequency of appliance use; 4: Gender, household income and heating habits; 5: Household income and energy saving behaviour. However, while the factor loadings for household income are above the minimum 0.3 level for statistical significance, they do not meet Stevens' (2002) criterion for smaller samples. This suggests that the influence of household income on components 3, 4 and 5 is weaker than the relationships observed in components 1 and 2 between knowledge and energy saving behaviour, and the frequency of use of different appliances respectively.

Correlations between knowledge and energy saving behaviour observed in Table 5 using Spearman's rank tests are supported by the identification of component 1 in

Tables 8 and 9. Component 2 suggests that the frequency with which one appliance is used may be associated with that of another appliance. This might be explained by the positive behaviour 'spillover effect', through which the adoption of one environmental behaviour follows another (Poortinga et al., 2013). Finally, heating practices are influenced by gender as well as household income (component 4). Research specifically relevant to how gender influences heating practices is currently lacking. Nevertheless, the effect of gender on electricity saving behaviour has already been discussed in section 4.1, suggesting that women are more likely to perform pro-environmental behaviour which leads to energy saving in households (Olli et al., 2001; Thogersen & Gronhoj, 2010).

The outcome of the PCA suggests that household income may have an influence on aspects of energy saving habits and behaviour, as well as social practices.

Since the PCA does not allow us to determine the direction of any correlation between household income and other variables of interest in the survey, it was necessary to perform additional Chi-Square and Fischer exact tests. To that effect, the original eight household income categories were merged to form the following three groups: £0 to £19,999; £20,000 to £49,999; and £50,000 and above. These categories were chosen to reflect the distribution of household income across the survey sample; for example, 31% of respondents' household income (before tax) ranged from £20,000 to £29,999, while for another 24% of respondents, it ranged from £50,000 to £69,999. Assuming that there are two employed adults on average across the household survey, the lowest and the highest income groups applied for the statistical analysis, each represent approximately 20% of the UK population in 2014 (HM Treasury, 2014). In order to perform the Chi-Square and Fischer exact tests, these three income groups were cross-tabulated with the full range of variables in the survey pertaining to environmental predisposition and knowledge, environmental behaviours, attitudes and habits, and social practices (use, duration and ownership of appliances).

Overall, household income is only correlated significantly with three variables at the 5% level using the Fischer exact test, namely: knowledge of greenhouse gas emissions from domestic energy consumption; the number of laptops owned; and the number of electric showers in each household (Table 10). The first of these

correlations indicates that more respondents than expected in the lowest income group had a moderate level of knowledge, while those in the middle income group were, perhaps surprisingly, more likely to have no or little knowledge of greenhouse gas emissions, and less likely to have moderate knowledge. The number of laptops owned was greater in higher income households. Low and middle income households were most likely to own one laptop, while the highest income group were most likely to own two laptops or more. Similarly, 5 of the 7 respondents who have more than one electric shower were in the highest income group. Conversely, 10 of the 13 households who did not own an electric shower had an income of less than £50,000. However, almost 30% of the survey sample comprised tenants who could not influence decisions on the purchase of an electric shower, while homeowners have the option to decide whether or not to own one, and therefore the correlation with household income may be misleading in this case.

As an additional point, a recent study found that more affluent households are not motivated to invest in energy efficient household equipment since appliances only represent a small proportion of such households' disposable income. Conversely, low income households struggle to afford the upfront cost of energy efficient appliances and even if financial incentives are created to assist with the purchase of efficient devices, such households still desire to match the living standards of the middle class, thereby counteracting the savings from any efficiency gains (i.e. through the rebound effect) (Cayla et al., 2011).

Table 8. Pattern Matrix

	Components				
Variables of survey	1: Knowledge and energy saving behaviour	2: Frequency of appliance use	3: Household income and frequency of showering	4: Gender, household income and heating habits	5: Household income and energy saving behaviour
Done at least 3 things to reduce household's energy use	**0.93**				

Knowledge of energy saving in the home	**0.88**				
TV per week		**0.85**			
Oven use per week		**0.75**			
Electric shower per week			**-0.87**		
Gender				**-0.85**	
Set of temperature at home				0.72	
Fill the kettle completely for each use?					**0.92**
Household income			0.45	-0.43	0.50

Notes to Table 8: 'Rotation Method: Oblimin with Kaiser Normalisation. Rotation converged in 20 iterations'.

Values in bold are considered significant according to Stevens (2002) criterion that factor loadings should be at least 0.722 for a sample size of 50.

Table 9. Structure Matrix

	Components				
Variables of survey	1: Knowledge and energy saving behaviour	2: Frequency of appliance use	3: Household income and frequency of appliance use	4: Gender, household income and heating habits	5: Household income and energy saving behaviour
Done at least 3 things to reduce household's energy use	**0.92**				
Knowledge of energy saving in the home	**0.89**				
TV per week		**0.83**			
Oven use per week		**0.77**	-0.44		
Electric shower per week			**-0.84**		
Gender				**-0.82**	

Set of temperature at home				**0.77**	
Fill the kettle completely for each use?					**0.88**
Household income			0.55	-0.46	0.59

Notes to Table 9: 'Rotation Method: Oblimin with Kaiser Normalisation'.

Values in bold are considered significant according to Stevens (2002) criterion that factor loadings should be at least 0.722 for a sample size of 50.

Table 10. Household income: Fischer exact test results significant at the 5% level

Variable correlated against household income	Fisher's exact test value	Exact significance (2-sided)
Knowledge of greenhouse gas emissions	10.8	0.02
Number of laptops owned	11.2	0.04
Number of electric showers owned	11.4	0.04

4.4 Discussion of findings against the literature review

This study revealed that factors such as valuing the environment and awareness of household energy savings are associated with occupants' environmental behaviours and attitudes which have the purpose of reducing their household energy consumption. Residents in the survey adopted alternative behaviours which met their comfort levels without consuming more energy and through the purchase of more efficient appliances / equipment, while respondents also demonstrated a willingness to pay higher prices in order to save in their energy bills. The pro-environmental behaviour of participants in this study is not found to be influenced by their education level. However, household income can have a significant influence on the number of appliances purchased, as well as on the level of occupants' knowledge with respect to greenhouse gas emissions.

In particular, one of the findings of this study suggests that knowledge and energy saving behaviour are positively correlated. This is supported by Olli et al. (2001, p.201) who stated that 'political attitudes, environmental concern, and environmental knowledge were mostly related to environmental behaviours'. However, the authors

pointed out as interesting results the importance of the correlation between social context and environmental behaviour. Moreover, the results of their study showed that education did not succeed in predicting environmental behaviour, and an insignificant or negative relationship between income and environmental behaviour exists.

Other more quantitative studies investigate correlations between socio-economic background variables and the level of energy consumption (e.g. Bartiaux & Gram-Hanssen, 2005). These studies demonstrate the dependence of energy use on other factors such as household income, type and size as well as the number of occupants. Household demographic characteristics are thus important factors to define the variation in household energy consumption; however these factors can only describe a proportion of this variation. The rest should be explained by other factors, such as users' values and knowledge (Gram-Hanssen et al., 2004).

That knowledge is a significant factor in explaining how domestic energy consumption varies, is further confirmed by the findings of an empirical study conducted by Abrahamse et al. (2007). The intervention methods (e.g. information, feedback and so on) used by the authors were successful in raising the knowledge of householders on energy use, which resulted in altering their energy consuming behaviour.

The education level of respondents in the current study was not found to be statistically associated with energy behaviours, attitudes or habits, however higher education has been found to be associated with environmentally friendly attitudes (Lutzenhiser 1993; Mills and Schleich 2010; and Weber and Perrels 2000). In addition, there were no significant correlations between knowledge and education. Nevertheless, other research identifies that the purchase of efficient domestic appliances is a product of the relative level of customers' knowledge and education, and information provided through energy labelling (Welsch & Kühling, 2010; Gram-Hanssen et al., 2007). This is important given substantial increases in electricity consumption due to the growth of domestic appliances (Energy Saving Trust, 2006).

In particular, higher education has been linked to greater understanding of appliance energy labels (Mills & Schleich, 2010), while people with university education have

been shown to make less mistakes with their purchase decisions (Welsch & Kühling, 2010). Moreover, highly educated people are likely to have more interest in being informed about the environmental impact or the electricity consumption of an energy product or service (Mansouri et al., 1996). While no significant correlation was observed in our study between the education level and environmental predisposition or attitudes, Lutzenhiser (1993) and Weber & Perrels (2000) found that higher education was associated with environmentally friendly attitudes (Mills & Schleich, 2010). Those with favourable environmental attitudes may be more likely to spend more on a green product, demonstrating that price and cost factors are also important (Gadenne et al., 2011). Furthermore, knowledge of energy labelling might be associated with multiple factors, including higher education, electricity prices, and income, as well as greater household size (Mills & Schleich, 2012; Scott, 1997; OECD, 2011).

Household income may also influence energy saving habits and behaviour, and social practices based around the use and ownership of appliances, according to the principal components analysis. Although this correlation appeared to be less significant, it is identified that income can influence behavioural energy performance in terms of energy practices and habits. This outcome is supported by a recent study which revealed that affluent households show a tendency towards lower energy savings than less well-off households because they can afford higher energy bills (Martinsson, Lundqvist, & Sundström, 2011).

In order to be successful, public information and education campaigns aimed to reduce household energy consumption should seek to influence attitude and behaviour which can co-exist with more traditional, existing pricing incentives. Energy companies and government bodies have a role in such campaigns to disseminate knowledge and information to enable householders to alter the energy behaviours (Webb et al., 2013).

CHAPTER 5: CONCLUSIONS & FURTHER RESEARCH

The purpose of this thesis was to develop and apply a theoretical framework (objective 1) for pro-environmental behaviour to an empirical study of residents based on an educational organization. The study sample consists of 68 employees of an educational institution, corresponding to a medium-sized enterprise, which was selected as the first phase of research with the wider aim of comparing energy saving behaviour at home and in the workplace. The current study relates only to the domestic aspects of this work.

The findings of the empirical study compare individuals' environmental knowledge and predisposition with their energy behaviour, attitude and habits (objective 2); and social practices related to the use and ownership of appliances (objective 3). In addition, the study attempts to correlate socio-demographic variables (objective 4), such as education level and household income with the above variables.

In relation to objective 2, the statistical analysis reveals significant correlations between environmental value and knowledge, and elements of individuals' energy attitudes, habits and behaviour. Following on from objective 3, the respondents' predisposition and attitudes is further correlated with social practices associated with domestic appliances. However, a relationship between individuals' energy habits and household consumption practices was not indicated by significant correlations. This is because such practices may involve a wide range of connected activities since people often carry out different energy consuming practices at the same time (e.g. cooking and doing the laundry while the TV and/or computer is on). With respect to objective 4, no significant correlations were established to demonstrate that education level may influence environmental predisposition and knowledge, or energy saving attitudes, habits and behaviours. In addition, an unanticipated outcome from the principal component analysis was that household income, and to a lesser extent gender, are associated with energy saving habits and behaviours. On further investigation, household income was found to be correlated with knowledge of greenhouse gas emissions and the number of laptops and electric showers owned per household.

In terms of interpreting the findings, it should be recognised that the principal component analysis (PCA) is exploratory, which means that its evaluation needs to be considered alongside the other statistical findings, and interpreted with respect to the relevant theoretical background from the literature review. Another reason for the outcome of the PCA to be treated with caution is that the sampling adequacy is rated by Field (2009) as 'mediocre', and cannot be generalised to the wider population.

In addition, since we cannot assume a direct correlation between social practices and appliance use, the study could benefit from conducting interviews with a sample of survey respondents to capture their qualitative views and combine and/or compare them with the data they provide in the survey. A mixed method research design is recommended by Creswell 2014, (p.220) who presents three alternative approaches. These methods include the convergent parallel mixed method (comparing or relating quantitative and qualitative data for interpretation); the explanatory sequential mixed method (collecting and analysing quantitative data followed by qualitative data collection to further interpret the quantitative findings); and the exploratory sequential mixed method (collecting first qualitative data which can be developed by additional quantitative data collection for interpretation). This could enhance the results and further inform the design of intervention methods which would aim to reform inefficient energy habits and encourage more environmentally friendly behaviours.

With respect to areas for further research, the analysis of this study highlights an inverse correlation between knowledge of household energy saving and the perceived inconvenience of reducing energy consumption. It was identified that there is a research gap in the literature with respect to how 'comfort' experiences in households are related to occupants' knowledge of how to save energy. For example, while the heating is on, householders may want to ventilate a space without reducing or turning off the heating, which leads them to open the windows, thereby wasting energy.

Moreover, there is a lack of relevant literature to evaluate the correlations between environmental predisposition and knowledge, and household appliance use. There could be merit in conducting further research to investigate how the frequency, duration and ownership of appliances are influenced by residents' environmental values and knowledge of energy saving in the home.

The finding of the statistical analysis also reveals a significant factor loading between gender and household heating practices. There is potential for additional research on how heating practices vary according to psycho-social or socio-economic aspects of gender differences, considering interactions between household members.

Finally, the wider aim is to compare the results from this study with additional empirical research on energy habits and practices within the working environment of the educational institution studied. The purpose of the future research is to establish the extent to which energy practices in the workplace are influenced by the corresponding energy activities at home, as well as how energy behaviours at work are influenced by peer groups, and whether or not this leads to pro-environmental behavioural change in the household.

REFERENCES

Abrahamse, W., Steg, L., Vlek, C., & Rothengatter, T. (2005). A review of intervention studies aimed at household energy conservation, *Journal of Environmental Psychology*, 25: 273–291.

Abrahamse, W., Steg, L., Vlek, C., & Rothengatter, T. (2007). The Effect of Tailored Information, Goal Setting, and Tailored Feedback on Household Energy Use, Energy-related Behaviours, and Behaviour Antecedents. *Journal of Environmental Psychology*, 27 (4): 265–276.

Abrahamse, W., & Steg, L. (2009). How do socio-demographic and psychological factors relate to households' direct and indirect energy use and savings? *Journal of Economic Psychology*, 30: 717-720.

Ajzen, I. (1985). From intentions to actions: a theory of planned behavior. In: Kuhl, J., Beckman, J. (Eds.), Action Control: From Cognition to Behavior. Springer, Heidelberg.

Arnould, E J., & Thompson, C J. (2005). Consumer Culture Theory (CCT): Twenty years of research. *Journal of Consumer Research*, 31, 868-882, University of Chicago, Press. Available from http://www.jstor.org/stable/10.1086/426626 (Accessed on 19th April 2013).

Arbuthnott, K. D. (2009). Education for sustainable development beyond attitude change. *International Journal of Sustainability in Higher Education*, 10: 152-163.

Axelrod, L. J., & Lehman, D. R. (1993). Responding to environmental concerns: what factors guide individual action? *Journal of Environmental Psychology*, 13 (2): 149-159.

Backlund, S., Thollander, P., Palm, J., & Ottosson, M. (2012). Extending the energy efficiency gap. *Energy Policy*, 51: 392-396.

Baker, K J., & Rylatt, R M. (2008). Improving the prediction of UK domestic energy-demand using annual consumption-data, *Applied Energy*, 85: 475–482.

Bakkenes, M., Eickhout, B., & Alkemade, R. (2006). Impacts of different climate stabilisation scenarios on plant species in Europe. *Global Environmental Change*, 16: 19-28.

Bamberg, S., & Moser, G. (2007). Twenty years after Hines, Hungerford and Tomera: A new meta-analysis of psycho-social determinants of pro-environmental behaviour. *Journal of Environmental Psychology*, 27 (1): 14-25.

Bandura, A. (1977 b). *Social Learning Theory*. Englewood Cliffs, NJ: Prentice Hall.

Barr, S., Gilg, A.W., & Ford, N. (2005). The Household Energy Gap: Examining the Divide between Habitual and Purchase-related Conservation Behaviours. *Energy Policy*, 33 (11): 1425–1444.

Barr, S., & Gilg, A. (2006). Sustainable lifestyles: Framing environmental action in and around the home. *Geoforum*, 37: 906–920.

Barr, S. (2007). Factors influencing environmental attitudes and behaviors: a UK study of household waste management. *Environment and Behavior*, 39 (4): 435-473.

Bartiaux, F. (2008). Does environmental information overcome practice compartmentalisation and change consumers' behaviours? *Journal of Cleaner Production*, 16 (11): 1170-1180.

Bartiaux, F., & Gram-Hanssen, K. (2005). Socio-political factors influencing household electricity consumption. A comparison between Denmark and Belgium. in *Eceee 2005 Summer Study Proceedings. Energy Savings: What works & who delivers, 30 May - 4 June 2005, Mandelieu la Napoule, France*, 3: 1313-1325.

Bauen, A. (2006). Future energy sources and systems—Acting on climate change and energy security. *Journal of Power Sources*, 157: 893–901.

Benders R. M. J., Kok, R., Moll, H. C., Wiersma, G., & Noorman, K. J. (2006). New approaches for household energy conservation – In search of personal household energy budgets and energy reduction options. *Energy Policy*, 34: 3612-3622.

Biggart, N. W., & Lutzenhiser L. (2007). Economic sociology and the social problem of energy inefficiency. *American Behavioural Scientist*, 50: 1070–1087.

Blok, V., Wesselink, R., Studynka, O., & Kemp, R. (2014). Encouraging sustainability in the workplace: a survey on the pro-environmental behaviour of university employees. *Journal of Cleaner Production*, 1-13. In press.

Bourdieu, P. (1984). *Distinction: a social critique of the judgement of taste*. Harvard College and London: Routledge & Kegan Paul Ltd.

Brechling, V., Smith, S. (1994). Household energy efficiency in the UK. *Fiscal studies*, 15: 44-56.

Cabeza, L.F., Urge-Vorsatz, D., McNeil, M.A., Barreneche, C., & Serrano, S. (2014). Investigating greenhouse challenge from growing trends of electricity consumption through home appliances in buildings. *Renewable and Sustainable Energy Reviews*, 36: 188-193.

Cayla J.-M., Maizi, N., & Marchand, C. (2011). The role of income in energy consumption behaviour: Evidence from French households data. *Energy Policy*, 39: 7874-7883.

Chan, K. (1998). Mass communication and pro-environmental behaviour: waste recycling in Hong Kong. *Journal of Environmental Management*, 52: 317-325.

Chen, J., Taylor, J. E., & Wei, H.-H. (2012). Modeling Building Occupant Network Energy Consumption Decision-making: The Interplay between Network Structure and Conservation. *Energy and Buildings*, 47: 515–524.

Clark, F.C., Kotchen, J.M., & Moore, M.R. (2003). Internal and external influences on pro-environmental behavior: Participation in a green electricity program. *Journal of Environmental Psychology*, 23 (3): 237–246.

Clarke, L., Edmonds, J., Krey, V., Richels, R., Rose, S., & Tavoni, M. (2009). International climate policy architectures: overview of the EMF 22 International Scenarios. *Energy Economics*, 31: (Suppl. 2):S64-S81.

Coleman, M., Brown, N., Wright, A., & Firth, S. K. (2012). Information, communication and entertainment appliance use – Insights from a UK household study. *Energy and Business*, 54: 61-72.

Commission recommendation 2003/361/EC (2003). *Official Journal, I.* 124: 36-41.

Communities and Local Government (CLG) (2012). Available from https://www.gov.uk/government/statistical-data-sets/live-tables-on-dwelling-stock-including-vacants (Accessed on 7th August 2014).

Creswell, J. (2014). *Research Design – Qualitative, Quantitative, and Mixed Methods Approaches*. International Student Edition (4th Edition). SAGE Publications, Inc.

Darnton, A. (2008). Reference Report: An Overview of Behaviour Change Models and their Uses. *Governmental Social Research (GSR) Behaviour Change Knowledge Review*. Centre for Sustainable Development, University of Westminster.

De Almeida, A., Fonseca, P., Schlomann, B., & Feilberg, N. (2011). Characterization of the household electricity consumption in the EU, potential energy savings and specific policy recommendations. *Energy and Buildings*, 43, 1884-1894.

DECADE (1994). Domestic Equipment and Carbon Dioxide Emissions. First year report, Environmental Change Unit, University of Oxford, pp. 37-8.

DECC (2012). What are the factors influencing energy behaviours and decision-making in the non-domestic sector? A Rapid Evidence Assessment - Centre for Sustainable Energy (CSE) and the Environmental Change Institute, University of Oxford (ECI).

Diamantopoulos, A., Schlegelmilch, B.B., Sinkovics, R.R., & Bohlen, G.M. (2003). Can socio-demographics still play a role in profiling green consumers? A review of the evidence and an empirical investigation. *Journal of Business Research*, 56: 465–480.

Doyle, R., & Davies, A. R. (2013). Towards sustainable household consumption: exploring a practice oriented, participatory backcasting approach for sustainable home heating practices in Ireland. *Journal of Cleaner Production*, 48: 260-271.

Dowd, A., Ashworth, P. Carr-Cornish, S., & Stenner, K. (2012). Energymark: Empowering Individual Australians to Reduce their Energy Consumption. *Energy Policy*, 51: 264–276.

Druckman, A., Chitnis, M., Sorrell, S., & Jackson, T. (2011). Missing carbon reductions? Exploring rebound and backfire effects in UK households. *Energy Policy*, 39: 3572-3581.

EEA (2013). Achieving energy efficiency through behaviour change: what does it take? EEA Technical report. No 5/2013. Luxembourg: Publications Office of the European Union, 2013. (Available from www.europa.eu).

Ellegard, K., & Palm, J. (2011). Visualizing energy consumption activities as a tool for making everyday life more sustainable. *Applied Energy*, 88: 1920-1926.

Elster, J. (1986). *Rational Choice*. Oxford: Basil Blackwell.

Energy Saving Trust (EST) (2012). Powering the nation – household electricity-using habits revealed. Report by Energy Saving Trust (EST) – Department of Energy & Climate Change (DECC) – Department for Environment Food & Rural Affairs (DEFRA).

Energy Saving Trust (EST) (2006). The rise of the machines - A review of energy using products in the home from the 1970s to today. Available from http://www.energysavingtrust.org.uk/Publications2/Corporate/Research-and-insights/The-rise-of-the-machines-a-review-of-energy-using-products-in-the-home-from-the-1970s-to-today (Accessed on 7th August 2014).

Feng, Z-H., Zou, L-L., Wei, & Y-M. (2011). The impact of household consumption on energy use and CO_2 emissions in China. *Energy*, 36: 656-670.

Festinger, L. (1957). *A Theory of Cognitive Dissonance*. Stanford: University of California Press.

Field, A. (2009). *Discovering Statistics Using SPSS* (3rd Edition). SAGE Publications, London.

Firth, S., Lomas, K.,Wright, A., & Wall, R. (2008). Identifying trends in the use of domestic appliances from household electricity consumption measurements. *Energy and Buildings*, 40 (5): 926–36.

Gadenne, D., Sharma,B., Kerr, D., & Smith, T. (2011). The Influence of Consumers' Environmental Beliefs and Attitudes on Energy Saving Behaviours. *Energy Policy*, 39 (12): 7684–7694.

Giddens, A. (1984). *The Constitution of Society: Outline of the theory of Structure*. University of California Press, Berkeley, CA.

Goldblatt, D. (2003). A dynamic structuration approach to information for end-user energy conservation. European Council for an Energy Efficient Economy - Time to turn down energy demand, 1111–1121.

Gram-Hanssen, K., Kofod, C., & Nærvig Petersen, K. (2004). *Different Everyday Lives: Different Patterns of Electricity Use*. ACEEE Summer Study on Energy

Efficiency in Buildings. August 22-27, Pacific Grove, CA: American Council for an Energy-Efficient Economy.

Gram-Hanssen, K., Bartiaux, F., Jensen, O.M., & Cantaert, M. (2007). Do homeowners use energy labels? A comparison between Denmark and Belgium. *Energy Policy*, 35: 2879–2888.

Gram-Hanssen, K. (2008). Consuming technologies – developing routines. *Journal of Cleaner Production*, 16 (11): 1181-1189.

Gram-Hanssen, K. (2014). New needs for better understanding of household's energy consumption – behaviour, lifestyle or practices? *Architectural Engineering and Design Management*, 10 (1-2): 91-107.

Groat, L., & Wang, D. (2002). *Architectural Research Methods*. John Wiley & Sons, Inc, New York, NY.

Gronhoj, A. (2006). Communication about consumption: a family process perspective on 'green' consumer practices. *Journal Consumer Behaviour*, Social Science Research Network (SSRN), 5 (6): 491-503.

Crosbie, T. (2008). Household energy consumption and consumer electronics: The case of television. *Energy Policy*, 36: 2191-2199.

Guerra-Santin, O., & Itard, L. (2010). Occupants' behaviour: determinants and effects on residential heating consumption. Building research & Information, 38 (3): 318-338.

Gyberg, P., & Palm, J. (2009). Influencing households' energy behaviour-how is this done and on what premises? *Energy Policy*, 37: 2807–2813.

Hajer, M. (2011). *The Energetic Society*. In Search of a Governance Philosophy for a Clean Economy. Bilthoven: PBL Netherlands Environmental Assessment Agency.

Halme, M., Jasch, C., & Scharp, M. (2004). Sustainable homeservices? Toward household services that enhance ecological, social and economic sustainability. *Ecological Economics*, 51: 125-138.

Harford, T. (2008). *The Logic of Life: Uncovering the New Economics of Everything*. London: Little, Brown.

Heiskanen, E., & Mikko, J. (2003). Can services lead to radical eco-efficiency improvements? – a review of the debate and evidence. *Corporate Social Responsibility and Environmental*, 10: 186-198.

HM Treasury (2014). Impact on households: distributional analysis to accompany Budget 2014.

Hobson, K. (2003). Thinking Habits into Action: The Role of Knowledge and Process in Questioning Household Consumption Practices. *Local Environment (Carfax Publishing)*, 8 (1): 95–112.

Hodgson, G. M. (2007). Institutions and Individuals: Interaction and Evolution. *Organisation Studies*, 28 (11): 95–116.

Homans, G. (1961). *Social Behaviour: its elementary forms*. London: Routledge and Kegan Paul.

Hunt, A. (2005). Your Research Project – How to Manage it. Routledge, Oxford.

IEA: International Energy Agency (2009). *World energy outlook 2009*. Paris: OECD/IEA.

IPCC: Intergovernmental Panel on Climate Change (2014). Climate Change 2014: Synthesis Report. Contribution of Working Groups I, II and III to the Fifth Assessment Report of the Intergovernmental Panel on Climate Change [Core Writing Team, R.K. Pachauri and L.A. Meyer (eds.)]. IPCC, Geneva, Switzerland, pp. 151.

Jackson, T. (2005). Motivating Sustainable Consumption: A Review Of Evidence On Consumer Behaviour And Behavioural Change. A report to the Sustainable Development Research Network. London: SDRN.

Jackson, T., & Marks, N. (1999). Consumption, sustainable welfare and human needs – with reference to UK expenditure patterns between 1954 and 1994. *Ecological Economics*, 28: 421-441.

Jensen, B. B. (2002). Knowledge, Action and Pro-environmental behaviour, *Environmental Education Research*, 8 (3): 325-334.

Jensen, J. O. (2008). Measuring Consumption in Households: Interpretations and Strategies. *Ecological Economics*, 68 (1–2): 353–361.

Kass, R. A., & Tinsley, H. E. A. (1979). Factor analysis. *Journal of Leisure Research*, 11: 120–138.

Kennedy, E. H., Beckley, T. M., McFarlane, B.L., & Nadeau, S. (2009). Why we don't walk the talk: understanding the environmental values/behaviour gap in Canada. *Human Ecology Review*, 16 (2): 151-160.

Kollmuss, A., & Agyeman, J. (2002). Mind the gap: why do people act environmentally and what are the barriers to pro-environmental behaviour? *Environmental Education Research*, 8 (3): 239-260.

Kopsakangas-Savolainen, M., & Juutinen, A. (2013). "Energy consumption and savings: A survey-based study of Finnish households." *Journal of Environmental Economics and Policy*, 2 (1): 71–92.

Kowsari, R., & Zerriffi, H. (2011). Three Dimensional Energy Profile: A Conceptual Framework for Assessing Household Energy Use. *Energy Policy*, 39 (12): 7505–7517.

Kronenberg, J. (2007). Making consumption ''reasonable''. *Journal of Cleaner Production*, 15: 557-566.

Langevin, J., Gurian, P. L., & Wen, J. (2013). Reducing energy consumption in low income public housing: Interviewing residents about energy behaviours. *Applied Energy*, 102: 1358-1370.

Littleford, C., Ryley, T. J., & Firth, S. K. (2014). Context, control and the spillover of energy use behaviours between office and home settings. *Journal of Environmental Psychology*, 40: 157-166.

Linden, A.-L., Carlsson-Kanyama, A., & Eriksson, B. (2006). Efficient and inefficient aspects of residential energy behaviour: what are the policy instruments for change? *Energy Policy*, 34 (14): 1918–1927.

Lockton, D., Harisson, D., Stanton, N, (2008). Making the user more efficient: design for sustainable behaviour. *International Journal of Sustainable Engineering*, 1 (1): 3-8.

Lopes, M. A. R., Antunes, C.H., & Martins, N. (2012). Energy behaviours as promoters of energy efficiency: A 21st century review. *Renewable and Sustainable Energy Reviews*, 16: 4095–4104.

Lozano, R. (2006). Incorporation and institutionalisation of SD into universities: breaking through barriers to change. *Journal of Cleaner Production*, 14 (9-11): 787-796.

Lutzenhiser, L. (1993). Social and behavioral aspects of energy use. *Annual Review of Energy and Environment*, 18: 247–289.

Mansouri, I., Newborough, M., & Probert, D. (1996). Energy Consumption in UK Households: Impact of Domestic Electrical Appliances. *Applied Energy*, 54 (3): 211-285.

Mainieri, T., Barnett, E., Valdero, T., Unipan, J., & Oskamp, S. (1997). Green buying: the influence of environmental concern on consumer behaviour. *Journal of Social Psychology*, 137 (2): 189-204.

Marechal, K. (2010). Not Irrational but Habitual: The Importance of 'Behavioural Lock-in' in Energy Consumption. *Ecological Economics*, 69 (5): 1104–1114.

Marjainé Szerényi, Z., Zsóka, Á., & Széchy, A. (2011). Consumer behaviour and lifestyle patterns of Hungarian students with regard to environmental awareness. *Society and Economy*, 33 (1): 89-110.

Martinsson, J., Lundqvist, L. J., & Sundstrom, A. (2011). Energy saving in Swedish households. The (relative) importance of environmental attitudes. *Energy Policy*, 39: 5182-5191.

Martiskainen, M. (2007). Affecting consumer behaviour on energy demand. Final report to EdF Energy, *Sussex Energy Group, SPRU - Science and Technology Policy Research*, University of Sussex.

Mills, B., & Schleich, J. (2010). What's driving energy efficient appliance label awareness and purchase propensity? *Energy Policy*, 38 (2): 814-825.

Mills, B., & Schleich, J. (2012). Residential Energy-efficient Technology Adoption, Energy Conservation, Knowledge, and Attitudes: An Analysis of European Countries. *Energy Policy*, 49: 616–628.

Mohanty B. (2001). Standby power losses in household electrical appliances and office equipment. Economic and Social Commission for Asia and the Pacific (UN-

ESCAP). Regional Symposium on Energy Efficiency Standards and Labelling. French Agency for the Environment and Energy Management (ADEME).

Morton, G., & Griffiths, N. (2012). Achieving energy efficiency through behavioural change – what does it take? *European Environment Agency (AEA) report*, Ref: ED57438, Issue 1.

National Readership Survey (NRS) (2014). Available from http://www.nrs.co.uk/nrs-print/lifestyle-and-classification-data/social-grade/ (Accessed on 17th September 2014).

National Statistics (ONS) (2013). Families and Households. Statistical Bulletin. Available from http://www.ons.gov.uk/ons/dcp171778_332633.pdf (Accessed on 17th August 2014).

National Statistics (ONS) (2014). Regional Economic Indicators. Available from http://www.ons.gov.uk/ons/dcp171776_369754.pdf (Accessed on 17th August 2014).

Nisiforou, O. A., Poullis, S., & Charalambides, A. G. (2012). Behaviour, attitudes and opinion of large enterprise employees with regard to their energy usage habits and adoption of energy saving measures. *Energy and Buildings*, 55: 299–311.

Nye, M., Whitmarsh, L., & Foxon, T. (2010). Sociopsychological perspectives on the active roles of domestic actors in transition to a lower carbon electricity economy. *Environment and Planning A*, 42: 697-714.

OECD (Organisation for Economic Co-operation & Development), Energy for sustainable development (2007). *OECD contribution to the United Nations Commission on Sustainable Development 15*.

OECD (Organisation for Economic Co-operation and Development) (2011). *Greening Household Behaviour: The Role of Public Policy*. Paris: OECD.

Oguz, D., Çakci, I., & Kavas, S. (2010). Environmental awareness of university students in Ankara, Turkey. *African Journal of Agricultural Research*, 5: 2629-2636.

Oikonomou, V., Becchis, F, Steg, L., & Russolillo, D. (2009). Energy saving and energy efficiency concepts for policy making. *Energy Policy*, 37: 4787-4796.

Olli, E., Grendstad, G., & Wollebaak, D. (2001). Correlates of environmental behaviours: Bringing back social context. *Environment and behaviour*, 33: 181–208.

Ozaki, R. (2011). Adopting sustainable innovation: what makes consumers sign up to green electricity? *Business Strategy and the Environment*, 20 (1): 1–17.

Paavola, J., & Adger, W N. (2006). Fair adaptation to climate change. *Ecological Economics*, 56: 594-609.

Palm, J. (2010). The public-private divide in household behaviour: How far into home can energy guidance reach? *Energy Policy*, 38: 2858-2864.

Palmer, J., Terry, N., Kane, T., Firth, S., Hughes, M., Pope, P., Young, J., Knight, D., & Godoy-Shimizu, D. (2013). Electrical appliances at home: tuning in to energy saving - Further Analysis of the Household Electricity Use Survey. 3-146. Reference 475/09/2012.

Palmer, J., Terry, N., Armitage, P., & Godoy-Shimizu, D. (2014). Savings, beliefs and demographic change - Further Analysis of the Household Electricity Survey. 4-69. Reference 475/09/2012.

Peine, A., & Herrmann, M. A. (2012). The sources of use knowledge: Towards integrating the dynamics of technology use and design in the articulation of societal challenges. *Technological Forecasting & Social Change*, 79 (8): 1495-1512.

Poortinga, W., Whitmarsh, L., & Suffolk, C. (2013). The introduction of a single-use carrier bag charge in Wales: Attitude change and behavioural spillover effects. *Journal of Environmental Psychology*, 36: 240-247.

Pothitou, M., Kolios, A., Varga, L., & Gu, S. (2014). A framework for targeting household energy savings through habitual behavioural change. *International Journal of Sustainable Energy*, 1-15. DOI: 10.1080/14786451.2014.936867.

Quality Assurance Agency for Higher Education (QAA) (2008). The framework for higher education qualifications in England, Wales and Northern Ireland. Linney Direct, Mansfield.

REMODECE (Residential Monitoring to Decrease Energy Use & Carbon Emissions in Europe) (2008). Final Report.

Rhodes, C. (2014). Business Statistics – Economic Policy & Statistics, SN/EP/6152, House of Commons Library.

Robinson, J. (2007). The Effect of Electricity-Use Feedback on Residential Consumption: A Case Study of Customers with Smart Meters in Milton. *MSc Thesis*, University of Waterloo, Ontario, Canada.

Rogers, R. (1975). A protection motivation theory of fear appeals and attitude change. *Journal of Psychology*, 91: 93-114.

Rogers, D. S., Duraiappah, A. K., Antons, D. K., Munoz, P., Bai, X., Fragkias, M., & Gutscher, H. (2012). A vision for human well-being: transition to social sustainability. *Current Opinion in Environmental Sustainability*, (4): 61-73.

Sadorsky, P. (2012). Information communication technology and electricity consumption in emerging economies. *Energy Policy*, 48: 130-136.

Sardianou, E. (2007). Estimating energy conservation patterns of Greek households. *Energy Policy*, 35: 3778-3791.

Sapci, O., & Considine, T. (2014). The link between environmental attitudes and energy consumption behaviour. *Journal of Behavioural and Experimental Economics*, 52: 29–34.

Schlegelmilch, B. B., Bohlen, G. M., & Diamantopoulos, A. (1996). The link between green purchasing decisions and measures of environmental consciousness. *European Journal of Marketing*, 30: 35-55.

Scott, S. (1997). Household energy efficiency in Ireland: A replication study of ownership of energy saving items. *Energy Economics*, 19: 187-208.

Seyfang, G. (2010). Community action for sustainable housing: Building a low-carbon future. *Energy Policy*, 38: 7624-7633.

Shove, E. (1998). Gaps, barriers and conceptual chasms: theories of technology transfer and energy in buildings. *Energy Policy*, 26: 1105–1112.

Shove, E. (2003). Converging conventions of comfort, cleanliness and convenience. *Journal of Consumer Policy*, 26 (4): 395-418.

Shove, E., & Hand, M. (2003). The restless Kitchen: possession, performance and renewal. Department of Sociology, Lancaster University. Available from http://www.lancaster.ac.uk/staff/shove/choreography/restlesskitchens.pdf (Accessed on 27th September 2014).

Siero, F. W., Bakker, A. B., Dekker, G. B., & Van Den Burg, M. T. C. (1996). Changing organizational energy consumption behaviour through comparative feedback. *Journal of Environmental Psychology*, 16 (3): 235-246.

Silverstone, R., & Hirsch, E. (1992). *Consuming Technologies: Media and Information in Domestic Spaces*. London: Routledge.

Slini, T., Gianna, E., Papadopoulos, A. M., (2014). The impact of economic recession on domestic energy consumption. *International Journal of Sustainable Energy*, DOI: 10.1080/14786451.2014.882335 (Accessed on 19th October 2013).

Steg, L. (2008). Promoting household energy conservation. *Energy Policy*, 36: 4449-4453.

Steg, L., & Vlek, C. (2009). Encouraging Pro-environmental Behaviour: An Integrate Review and Research. *Journal of Environmental Psychology*, 29 (3): 309–317.

Stephenson, J., Barton, B., Carrington, G., Gnoth, D., Lawson, R., & Thorsnes, P. (2010). Energy cultures: A framework for understanding energy behaviours. *Energy Policy*, 38: 6120–6129.

Stern, P.C., Dietz, T., & Guagnano, G.A. (1995). The new ecological paradigm in social–psychological context. *Environment and Behaviour*, 27: 723–743.

Stevens, J. P. (2002). *Applied multivariate statistics for the social sciences* (4th Edition). Hillsdale, NJ: Erlbaum.

Swan, G. L., & V. Ugursal, I. (2009). Modeling of end-use energy consumption in the residential sector: A review of modeling techniques. Renewable and Sustainable *Energy Reviews*, 13 (8): 1819–1835.

Talbot, C., Canavan, E., Miles, K., (2007). Understanding Behavioural Change: Theoretical Principles and Guidelines for Policy. Clare Talbot at the DWP Strategy Unit.

Thogersen, J., & Gronhoj, A. (2010). Electricity Saving in Households – A Social Cognitive Approach. *Energy Policy*, 38 (12): 7732–7743.

Tsarenko, Y., Ferraro, C., Sands, S., & McLeod, C. (2013). Environmentally conscious consumption: The role of retailers and peers as external influences. Journal *of Retailing and Consumer Services*, 20: 302-310.

Yu, B., Zhang, J., & Fujiwara, A. (2011). Representing In-home and Out-of-Home Energy Consumption Behaviour in Beijing. *Energy Policy*, 39 (7): 4168–4177.

Yu, B., Zhang, J., & Fujiwara, A. (2012). Analysis of the Residential Location Choice and Household Energy Consumption Behaviour by Incorporating Multiple Self-selection Effects. *Energy Policy*, 46: 319–334.

van Vuuren, D P, Nakicenovic, N., Riahi, K., Brew-Hammond, A., Kammen, D., Modi, V., Nilsson, M., Smith, K. R. (2012). An energy vision: the transformation towards sustainability-interconnected challenges and solutions. *Current Opinion in Environmental Sustainability*, 4 (1): 18–34.

van den Bergh, J. C. J. M. (2008). Environmental regulation of households: An empirical review of economic and psychological factors. *Ecological Economics*, 66: 559-574.

Vicente-Molina, M. A., Fernández-Sáinz, A., & Izagirre-Olaizola, J. (2013). Environmental knowledge and other variables affecting pro-environmental behaviour: comparison of university students from emerging and advanced countries. *Journal of Cleaner Production*, 61: 130–138.

Wada, K., Akimoto, K., Sano, F., Oda, J., & Homma, T. (2012). Energy efficiency opportunities in the residential sector and their feasibility. *Energy*, 48: 5-10.

Webb, D., Soutar, G.N., Mazzarol, T., & Saldaris, P. (2013). Self-determination theory and consumer behavioural change: Evidence from a household energy-saving behaviour study. *Journal of Environmental Psychology*, 35: 59-66.

Weber, C., & Perrels, A. (2000). Modelling lifestyle effects on energy demand and related emissions. *Energy Policy*, 28: 549-566.

Welsch, H., & Kühling, J. (2010). Pro-environmental behavior and rational consumer choice: Evidence from surveys of life satisfaction. *Journal of Economic Psychology*, 31: 405–420.

Whitehead, J. C. (2005). Environmental Risk and Averting Behaviour: Predictive Validity of Jointly Estimated Revealed and Stated Behaviour Data. *Environmental & Resource Economics*, 32: 310-316.

Whitmarsh, L., Upham, P., Poortinga, W., McLachlan, C., Darnton, A., Devine-Wright, P., Demski, C., & Sherry-Brennan, F. (2011). *Public Attitudes,*

Understanding, and Engagement in Relation to Low Carbon Energy:A Selective Review of Academic and Non Academic Literatures. Report for Research Council UK (RCUK) Energy Programme. Swindon: Research Councils UK.

Wilkinson, D., & Birmingham, P. (2003). Using Research Instruments. A Guide for Researchers. Routledge Falmer, London.

Wilson, C., Dowlatabadi, H. (2007). Models of Decision Making and Residential Energy Use. *Annual Review of Environment and Resources*, 32: 169–203.

Wilson, C. M., Waddams Price, C. (2010). Do consumers switch to the best supplier? *Oxford Economic Papers*, 62 (4): 647-668.

Wood, G., & Newborough, M. (2003). Dynamic energy-consumption indicators for domestic appliances: environment, behaviour and design. *Energy and Buildings*, 35: 821-841.

Zhang, T., Siebers, P. O., & Aickelin, U. (2012). A Three-dimensional Model of Residential Energy ConsumerArchetypes for Local Energy Policy Design in the UK. *Energy Policy*, 47: 102–110.

Zsóka, A., Marjainé Szerényi, Z., Széchy, A., & Kocsis, T. (2013). Greening due to environmental education? Environmental knowledge, attitudes, consumer behaviour and everyday pro-environmental activities of Hungarian high school and university students. *Journal of Cleaner Production*, 48: 126–138.

APPENDIX

Appendix A. Energy Habits / Attitudes versus Social Practices

Type of Appliance	Description of the correlation	Hypothesis	Example References	Expected direction of correlation	Correlation result (Spearman's rank unless stated)	Observations (Chi-square & Fischer's exact test only)	Significance level (1 tailed for Spearman's rank / 2 tailed for Chi-square & Fischer's exact test)	Number of cases (%)
TV	Price is more important than energy efficiency versus duration of watching TV	1) ***People who value energy efficiency greater than price when choosing products are more likely to watch TVs extensively. However, this may be complicated by the rebound effect.*** 2) Null hypothesis	Cabeza, et al., 2014.	1) Positive 2) N/A	1) 0.36 2) 8.7	2) The higher number of people than expected who considered that price is more important, watched TV for a longer duration (2–5+ h.). Conversely, those who disagreed that price is more important were more likely to watch TV for 2h or less per use.	1%	76.1
Laptop	Save money by reducing household energy use versus frequency of laptop use	***The more people care about saving money, the less the frequency of use.***	Gram-Hanssen, 2008.	Positive	-0.33		1%	80.6
Electric Shower	1) Reducing household energy consumption would be inconvenient versus frequency of showers 2) Price is more important than energy efficiency versus duration of showers	1) ***The more people consider that saving energy is inconvenient, the more likely they are to shower more often.*** 2) ***Duration of showering is likely to be greater if people value price over the energy efficiency.***	N/A	Positive	1) -0.38 2) 0.53		1%	1) 65.7 2) 59.7
Electric Shower	Reducing household energy consumption would be inconvenient versus frequency of showers	Null hypothesis	N/A	N/A	10.4	More people than expected disagreed / strongly disagreed that it was inconvenient to reduce their energy use, showered once per day or more often. Respondents who	5%	65.7

						either agreed or disagreed were more likely to shower less frequently.		
Vacuum Cleaner	Willingness to change habit / attitudes to reduce household energy consumption versus frequency of vacuuming	***The more willing to change habits / attitudes to reduce energy use, the less frequent the use of a vacuum.***	N/A	Negative	0.33		1%	80.6
Vacuum Cleaner	Reducing household energy consumption would be inconvenient versus duration of use of vacuum cleaner	Null hypothesis	N/A	N/A	6.3 (Fischer)	A higher number of respondents than expected, who strongly disagreed to the contention, used a vacuum cleaner for less than half an hour. Conversely, a lower number than expected of those who disagreed hovered for 30m.–2h.	5%	77.6
Microwave	Done at least 3 things to reduce household energy use versus frequency of microwave use	1) ***The more things done to reduce energy use, the less likely they are to use the microwave often.*** 2) Null hypothesis	Gram-Hanssen, 2008.	1) Negative 2) N/A	1) -0.34 2) 11.3 (Fischer)	The higher people than expected who strongly agreed to do at least 3 things used a microwave at least once per day or more frequently. Conversely a lower number than expected use the microwave one per week or less often.	1%	82
Tumble Dryer	Done at least 3 things to reduce household energy use versus frequency of tumble dryer use	Null hypothesis	N/A	N/A	9.8 (Fischer)	More people than expected who claimed they took actions to reduce their energy consumption, use the tumble dryer 2-6 times people	5%	64.2
Washing Machine	Done at least 3 things to reduce household energy use versus duration of use of washing machine	Null hypothesis	Gram-Hanssen, 2008.	N/A	7.5 (Fischer)	A higher number of people than expected, who agreed / strongly agreed to do at least 3 things, used a washing machine for less amount of time (30m.-2h.)	5%	83.6