ETHICAL VALUES AS FACTORS FOR ACCEPTANCE OF SMART ENERGY SYSTEMS

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Ethical Values as factors for acceptance of Smart Energy Systems

By

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Executive Summary

In the smart energy paradigm, consumers will play a very central role. Therefore, in case of technologies that are part of smart energy systems like the smart home energy management system (HEMS), its deployment hinges on the end user’s acceptance of the technology. However, HEMS is an unfamiliar technology having barriers for acceptance for consumers like privacy, data security, etc. Ethical Values like the ecological sustainability, distributive justice can act as drivers for acceptance while the lack of values like privacy, trust can negatively affect the acceptance of technology. Thus, the research objective was to develop an ethical values integrated technology acceptance framework. The main research question focused on determining what is the relative influence of ethical values on the acceptance of smart HEMS by end users.

The theoretical model developed in this research is a composite model incorporating ethical values (privacy, sustainability, trust, fairness, and autonomy), technological characteristics (compatibility and feedback) and knowledge with the constructs of Theory of Planned Behaviour (TPB) with Norm Activation Model (NAM). Measures were developed for measuring these constructs through a questionnaire. The developed questionnaire was distributed based on convenience sampling to the individuals in the network of the researcher. 173 responses was recorded through a combination of electronic and paper-based surveys.

The methods used for data analysis consisted of Exploratory Factor Analysis (EFA) using IBM SPSS Statistics 23 for uncovering the underlying structure in data and Structural Equation Modelling (SEM) using IBM SPSS AMOS 23 for empirically validating the model. Additionally, one way ANOVA were performed to see the effect of demographic variables on the dependent variables.

Results from EFA reveal that the constructs that are theoretically distinct are also empirically distinct. The final SEM model had relatively good fit ($\chi^2=34.1; \text{df}=18; p=.019$; RMSEA = 0.077; SRMR = 0.066; NFI = 0.907; CFI = 0.951; GFI = 0.955). The path model also revealed that out of the 5 identified ethical values only Trust, Fairness and Sustainability had a significant effect on Attitude (and indirect effect on Intention to buy). Feedback was also found to have significant effect on attitude. ANOVA revealed that Age has an effect of on Perceived Behavioural Control ($F(3, 146) = 4.06, p < .05$), on Personal Norms ($F(3, 146) = 7.482, p < .05$), and on Intention to Buy ($F(3, 146) = 4.607, p < .05$). Housing condition was also found to affect Perceived Behavioural Control ($F(2, 147) = 3.291, p < .05$) through ANOVA.
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1. Introduction

The existing electrical grids all around the world were built more than 100 years ago and have continued to grow in size since then. These conventional electrical grids consist of power plants that generate electricity using coal, natural gas or more recently nuclear energy as their main primary energy source. Since their conception, these grids have had the same structure even though the power/voltage being delivered through them has increased consistently over the century. The conventional energy sources that are employed by these grids are, generally, stable sources and can be added or removed from the grid depending on the requirement of the hour.

In recent years, however, the focus of most of the major countries has shifted towards incorporating green, clean and renewable energy sources like solar or wind (Came, 2011; TU Delft, n.d.). Greener energy sources like solar or wind energy are different from the traditional sources in a sense that not only they are cleaner, greener but they are also unstable and inconsistent (Tverberg, 2016). These sources of energy can also be not added or removed from the grid as and when required. Using more renewable sources also means that there will be a shift from a centralised power generation to a more decentralised and flexible power generation using more renewable energy sources (Nye et al., 2010; Obinna et al., 2016). This represents a key technological challenge for energy systems in near future (Mathiesen et al., 2015).

To better integrate renewable energy sources and to combat increasing demand for electricity, many solutions have been proposed like Smart Energy Systems1, Smart Grids2, and others. These solutions include technologies that enable coping with intermittencies and decentralization on the supply side as well as increasing energy efficiency on the demand side. European Union’s Energy Road Map 2050 along with Directive 2010/31/EU for energy performance of building and European Standard 15232 all promote incorporating smart home technologies to decrease electricity usage in residential sector (Comité Européen de Normalisation, 2006; European Commission, 2010). One such smart home technology is the Home Energy Management System.

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1 Smart energy system is a smart combination of gas, thermal and electricity grids to allow coordination between them by identifying synergies between them and achieve optimal efficiency for the entire system as well as the individual components.
2 Smart Grids is an intelligent electric network with control, monitoring and analysis, so that electricity can be moved around the grid more efficiently and economically.
Smart Home Energy Management System (HEMS; discussed at detail in Section 2.1) allows for management of electricity grids on the demand side (Brooks et al., 2010). This technology enables to constantly monitor various electrical appliances in the home of a consumer and to arrange them based on the preferences of the user to reduce electricity usage and increase efficiency of electricity (Farhangi, 2010; Vojdani, 2008; Zhang et al., 2010; Li et al., 2015). HEMS is therefore a system that optimises energy management so as to monitor, store, consume and manage electricity in smart homes. Smart HEMS and its components enable decentralised power generation (which occurs at the residence of the consumer). This has led to the rise of term “prosumer”, i.e. consumers can act as both producers and consumers.

1.1. Research Objective

With the central role of consumers in smart energy paradigm, the deployment of the smart home energy management system and its components hinges on the end user’s acceptance of the technology (Park et al., 2014). Acceptance³ in this research is defined as either supportive (buying the technology or using the technology) or opposing behaviour of the end user towards smart HEMS. For an average residential customer, HEMS and its components are unfamiliar technologies having barriers for acceptance such as data security, threats related to privacy or reluctance of accepting new technology (McCarthy, 2011; Ricketts, 2009; Weaver, 2014). This can be observed in the resistance towards installation of smart meters in virtually every country that it has been introduced (Kranz et al., 2010; Toft et al., 2014; Chou et al., 2015). This resistance of the public towards the acceptance of technology can impede upon its widespread adoption and thereby affect the realisation of environmental and societal goals (Schweizer-Ries, 2008; Wüstenhagen et al., 2007).

Innovation management literature is littered with various technology acceptance models. Various scholars have delineated factors for explaining the acceptance of the technology in the society (Davis, 1989; Schilling, 1998; Suarez, 2004; Venkatesh & Davis, 2000; Venkatesh et al., 2003). The rational decision making constructs within the Theory of Reasoned Action (TRA), Theory of Planned Behaviour (TPB), Technology Acceptance Model (TAM), Unified Theory of

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³ Acceptance is defined as the behaviour towards smart home energy management systems. The behaviour of the consumer towards the technology could be supportive (in that they buy/ use the product) or opposed to the technology (not buy the technology)
Acceptance and Usage of Technology (UTAUT) and others have long been used to describe the intention to use certain technology. However, technology and its acceptance in the society is not only affected by these existing constructs but is also affected by irrational and subjective factors like values and emotions (Park et al., 2014). TAM, TRA and TPB have long been criticised for their lack of moral considerations and exclusion of unconscious influences on behaviour due to the emotions or values of the individual (Conner et al., 2013; Manstead, 2000). Lack of consideration in terms of societal and ethical aspects of the technology has led to rejection of smart energy technologies in the past. For example, Dutch government had to back off from their decision of mandatory smart meters deployment due to privacy concerns raised by the parliament members and general public.

In addition, we have the normative decision models like the Normative Activation Model (NAM) and Value-Belief-Norm (VBN). According to these models, the motivation to perform certain behaviour depends on how strong the individual believes that the public benefit would be if he performed the behaviour. Even though these models have been widely used to predict pro-environmental behaviours, they still have been criticised for over-playing the role of personal norms (individual’s belief about what is right or wrong).

Consumer’s decision to use certain product can be greatly affected by the values of the said consumer (Honkanen et al., 2006; Vermeir & Verbeke, 2006). There has been an impetus on designing technologies in such a manner that they support enduring human values (Friedman et al., 2013). Friedman et al. (2003) go on to describe a set of 12 human values with ethical import which should be taken into account while designing technologies (Calmness, Accountability, Human Welfare, Autonomy, Privacy, Trust, Freedom from Bias, Informed consent, Ownership & Property, Identity, Universal Usability, and Sustainability). But once a technology is already developed, the ethical values that it embodies takes the form of technological characteristics and these can be greatly affect its acceptability in society. Ethical Values like the ecological sustainability, distributive justice can act as drivers for smart energy systems (Xenias et al., 2015) while the values of privacy, trust can negatively affect the acceptance of technology (Buchanan et al., 2016; Chou et al., 2015).

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4 Ethical values often require that we stretch our own interests to protect, serve, help and respect others. These values help the individual to establish a compass in terms of what are “right” things to do and the things “worth” doing
Thus, the research objective is to develop an ethical values integrated technology acceptance framework which incorporates both normative and rational influences on for smart home energy management systems and testing its applicability. By conducting a literature review of factors that affect technology acceptance in general and ethical values associated with smart home energy management systems can be explored whether these values can be integrated into existing models of technology acceptance. The results would then be synthesized into an overall model. Subsequently, the model will be applied to study the acceptance of smart home energy management systems resulting in an exploration of both completeness and relevance of the model.

1.2. Research Questions

Technological systems though designed with purpose of serving certain function, often embody ethical values (Friedman & Kahn, 2003). This is discussed in detail in Section 2.4 and Section 2.5. Once the technology is designed depending on the ethical values it embodies it may never take hold in the society (Friedman & Kahn, 2003). Thus, ethical values can have an impact on the acceptance of a smart technology. To understand this impact this reports concentrates on identifying,

“What is the relative influence of ethical values on the acceptance of smart home energy management systems by end users?”

To understand this influence of ethical value on acceptance, I first review models that aim at explaining the behavioural intentions of the individual or acceptance of technology by that individual. The aim is to identify a base model for the research into which the values will be integrated. This forms the basis of the first sub question,

a. What behavioural models are relevant for studying the end user’s acceptance of smart home energy management systems?

It is important to identify ethical values which are prevalent in the society in context of smart home energy management systems. For this, a literature review will be conducted to identify these values in context of end users, include them in the model and answer the following sub question,

b. What are ethical values relevant to the end user’s acceptance of smart home energy management systems?
In addition, factors other than ethical values like technological characteristics (feedback, relative advantage, etc.) may play a significant role in the acceptance of technology,

c. What are the technological characteristics that are relevant for end user’s acceptance of smart home energy management systems?

Factors and values obtained in sub-questions b & c may not be a comprehensive list of all relevant things.

1.3. Relevance

The development of an ethical values integrated technology acceptance model will add to the growing literature in the field of technology acceptance. To my knowledge this would be the first time such an integration is carried out to study the effect of ethical values on acceptance. Such a model though developed for smart energy systems can also be used as a framework to study the acceptance of other technologies that have social or environmental benefits/ pitfalls. The results from this research would also have practical relevance in terms that it will help the companies understand the consumer decision process in a better way. The factors (technological and values) can be used as starting points in design process for future technologies to improve their consumer acceptance.

1.4. Research Design

The design of this research is divided into two parts. The first part consists of an extensive literature survey to review the models that explain individual’s behaviour and acceptance of technology and to delineate the ethical values relevant to the domain of smart energy systems. In the second part, to understand the effect of these values on acceptance and to validate our model, a survey will be conducted. The research design is summarised in Figure 1.
1.5. Thesis Structure

Section 2 of the report begins with a detail description of the Smart Home Energy Management Systems. Then the behavioural models (rational and normative) that form the basis of this research are discussed and reviewed in detail. Finally, we discuss the importance of values in technology and the various ethical values that are concentrated upon in this research. We also discuss technological characteristics and demographic characteristics that may affect acceptance of technologies by end users.

Section 3 describes the theoretical model used for this research. Each construct and its linkages are explained with theoretical underpinning. The section also provides with visualisation of the model used.

Section 4 is the “Methodology” section which concentrates on the survey development. To validate the model developed in this research, a survey was developed, tested, and finally executed. This section describes in the detail this process and the reasoning behind the measured used in the survey. This section also describes the data analysis process and the methods used for the same.

Section 5 showcases the results of the analysis conducted on the data collected from respondents. The section begins with describing the demographic characteristics of the respondents. Then, an
exploratory factor analysis was conducted on the developed item measures to determine the number of factors that can describe the underlying structure between the variables. Based on the results of the factor analysis and reliability analysis, a structure equation model was developed in IBM AMOS SPSS to analyse the relationship between measured variables and latent constructs. Finally, a one way analysis of variance (ANOVA) test was conducted to determine the effect of the demographic characteristics on the dependent variables.

Section 6 summarises the results and describe the significance of the findings. It also discusses the limitations of the research, the theoretical significance and practical relevance of the study. The section ends with directions for future research.

Section 7 focuses on the conclusions of the report. The section also provides with limitations of the research and the avenues for further research.
2. Literature Review

The literature used for the review in this research stems from multiple sources from the fields of technology acceptance, behavioural theories, value based studies, social acceptance, and ethics of technology. The literature review would be part of answering the first three sub questions of the research relating to technology acceptance framework and relevant ethical values. The results from these i.e. ethical values integrated model would then be used to answer the fourth sub question.

The databases that will be utilised for the purpose of literature review are,

1. TU Delft Library
2. TU Delft Repository
3. Science Direct
4. Research Gate

Integrated search engines at these databases was used in conjunction with “Google Search” and “Google Scholar” for academic and additional web sources.

2.1. Smart Home Energy Management Systems

The idea of smart homes has been around for almost 3 decades. Satpathy (2006) describes smart homes as being capable enough to help its occupants to live an independent and comfortable life with the assistance of technology. In case of smart homes, interactive space is created by interconnecting various mechanical and digital appliances which are capable of communicating with each other as well as the user. Alam et al. (2012) suggest that smart homes enable the users using various technologies like remote home control, home automation or ambient intelligence.

Thus, the primary goal of a smart home is to improve the comfort of the inhabitants and make their daily lives easier. Lobaccaro et al. (2016) in their review of smart home technologies available in the market, classified them into four different categories:

1. Integrated wireless technology (IWT);
2. Home energy management system (HEMS);
3. Smart home microcomputers (SHMC);

Under the smart energy systems paradigm, advanced metering devices can provide a two-way communication channel between residential consumers and the power utilities (Kahrobaee et al.,
Thus, there exist economic incentives like increasing utilisation efficiency, conserving electricity and therefore reducing electricity bills to manage the demand-side in response to dynamic electricity pricing by shifting usage to off-peak hours (Tsui & Chan, 2012). This can be achieved by Smart HEMS. Smart Home Energy Management Systems (Smart HEMS) are optimised systems which provide with energy management capabilities to efficiently and smartly control and monitor electricity generation, its storage, and consumption in smart homes (Han et al., 2011; Son et al., 2010). Smart HEMS utilise the communication and sensing technologies for collecting information from domestic appliances related to energy consumption and use personal computers or even smart phones for monitoring and controlling the operation modes of these devices (Han et al., 2011). These systems not only provide with the energy utilisation optimisation capabilities but also are capable for storage and management of distributed energy resources (DERs) and Home Energy Storage System (HESS).

Figure 2 provides a schematic representation of a smart HEMS. At the centre of the Smart HEMS is a smart controller which provides modules with monitoring and control functionalities to home owner (Kuzlu et al., 2012). Smart meter which acts as a gateway is utilised as a communication
interface between the power utilities and smart home. The smart home may have many different schedulable loads (like Electric Vehicles, etc.) and non-schedulable loads (like refrigerators, etc.). Distributed electricity generation in the residential areas currently involves photovoltaic cell but the landscape may change with the rise of micro wind turbines. To maintain the reliability of the energy system and improve energy efficiency, energy storage devices play an important role (Missaoui et al., 2014).

2.2. Social Acceptance

As discussed earlier, HEMS and its components are relatively unfamiliar technologies for the public. There are barriers to public acceptance of these technologies like data security, threats related to privacy or reluctance of accepting new technology. These barriers can impede widespread adoption of the technology and thereby affect the realisation of environmental and societal goals. Thus, it is very important to study the acceptance of smart HEMS technology.

According to Sauter and Watson (2007), social acceptance can range from passive consent to an active involvement by the whole society of the technology in consideration. Wüstenhagen et al., (2007) provide with three dimensions of social acceptance: (1) Socio-political acceptance, (2) Community acceptance, and (3) Market acceptance. Socio-political acceptance is the acceptance of technologies and even policies by key stakeholders and policymakers (Wüstenhagen et al., 2007). Community acceptance refers to the acceptance of technologies, projects and decisions by local stakeholders (Wüstenhagen et al., 2007). This is similar to Stern et al.’s (1999) definition of citizen acceptance which is the acceptance of a technology or infrastructure close to one’s home which controlled or managed by others (nuclear plant, etc.) Market acceptance is the process of market adoption of an innovation (Wüstenhagen et al., 2007). Huijts et al. (2012) define consumer acceptance as the purchase or use of technological innovations.

In this research, consumer acceptance or market acceptance is defined as the behaviour towards smart home energy management systems. The behaviour of the consumer towards the technology could be supportive (in that they buy/use the product) or opposed to the technology (not buying the technology). This main independent variable of this research is the consumer’s intention to buy smart HEMS.
2.3. Behaviour Models

Many models have been proposed to study the behaviour and intentions of individuals. Broadly speaking models for studying behaviour can be classified in two kinds of models, rational models and normative behavioural models. The models for rational behaviour typically assume that the individuals whose behaviour is being studied are motivated by self-interests. The implication of this is that if there is an added benefit to act in a certain manner, the attitude of the individuals would be positive towards the behaviour. Thus, rational models postulate that individuals choose among alternatives through rationalization of costs and benefits.

Theory of Reasoned Action (TRA; Fishbein & Ajzen, 1975) and its subsequent extension as the Theory of Planned Behaviour (TPB; Ajzen, 1991) are widely used rational choice models. In this research, since the aim is to study the acceptance of smart energy systems, the Technology Acceptance Model (TAM; Davis, 1989) and the Unified Theory of Acceptance and Use of Technology (UTAUT; Venkatesh et al., 2003) were reviewed. Out of these models, TPB was chosen as the base model for this research. TPB is a direct upgrade over the TRA model as the former was created to overcome the limitations of the latter. TAM though considered parsimonious as compared to TPB and used widely to study acceptance, performs poorly in predicting intentions to use and behaviour (Kieran Mathieson, 1991; Taylor & Todd, 1995a). TPB however is more likely to capture more social variables than TAM. Where TAM succeeds in being parsimonious, UTAUT fails spectacularly as it includes 41 independent variables for predicting intentions and 8 variables for predicting behaviour making the technology adoption study chaotic (Bagozzi, 2007). All these reasons made TPB is better choice as a model for this research. Review for the TPB is provided in section 2.3.1, while the other models are reviewed in Appendix A.

Normative models for behaviour postulate that the behaviour of the individuals is in some a function of their moral beliefs. The obligation to perform certain behaviour depends on how strong the individual believes that the public benefit would be if he performed the behaviour. These models suggest that both altruistic and egoistic motives play a role in determining the behaviour. The Norm-Activation model (NAM; Schwartz, 1977) and Value-Belief-Norm model (VBN; Stern, 2000) are the most common examples of a normative models used for studying pro-social behaviours. Out of these models, NAM was chosen to be integrated with TPB. Section 2.3.2 provides with review of NAM while VBN is reviewed in Appendix A.
All of these models have been widely used to study behaviours and intention of individuals. Over the years, many authors have added (or removed) constructs to explain certain behaviours. Consequently, there are various forms of these models. In this paper for the review only the original models are considered.

2.3.1. Theory of Planned Behaviour

Ajzen conceived Theory of Planned Behaviour (TPB) as a logical extension to his earlier Theory of Reasoned Action (TRA) so as to overcome the limitations of the former theory in explaining behaviours over which individuals do not have any control. Theory of Planned Behaviour explains the Behavioural Intention (BI) using three antecedents viz. Attitude towards the Behaviour (AAct), Subjective Norms (SN) and the Perceived Behavioural Control (PBC) (Ajzen, 1991). Salient beliefs precede these antecedents - Normative Beliefs lead to Attitude towards the Behaviour, Behavioural Beliefs lead to Subjective Norms and Control Beliefs lead to Perceived Behavioural Control. A schematic representation of the theory can be seen in the Figure 3.

![Figure 3 Theory of Planned Behaviour, Adapted from Ajzen (1991)](image)

**Behavioural Beliefs and Attitude towards Behaviour**

Attitude toward the act (AAct) describes how the behaviour is valued (positively/ negatively) by the individual. Behavioural Beliefs are the individual’s beliefs about the outcome of a behaviour. These outcomes of the behaviour could be positive or negative in nature and therefore help individuals to form an attitude towards the behaviour. Naturally, behaviours with favourable outcomes would be preferred over the ones with less favourable outcomes.
Subjective Norms and the Normative Beliefs

Subjective Norm is the amount of social compulsion that is perceived by a person to perform certain behaviour or not. Subjective Norm is affected by the amount of normative beliefs about whether people important (referent) to the individual endorse or oppose a given behaviour.

Control Beliefs and Perceived Behavioural Control

Perceived Behavioural Control (PBC) is the extent to which the individual believes that he/she can perform the behaviour under consideration. PBC is affected by control beliefs which are concerned with the availability or absence of resources and opportunities. If the individuals perceive that they have more opportunities and resources, and that there are fewer obstacles, then their perceived behavioural control is higher.

Behavioural Intention

Behavioural intention (BI) indicates the extent to which an individual is ready to perform certain behaviour. It is considered as the direct predictor of behaviour.

Review

Much like the TRA, Theory of Planned Behaviour has been used in multiple studies across various scientific disciplines to study behaviour. Behavioural studies with the theory include use of condom (Albarracín et al., 2001b), exercise (Rhodes & Courneya, 2003), coupon usage (Hsu et al., 2006), drug and alcohol abuse (Mcmillan & Conner, 2003), cessation of smoking (Norman et al., 1999), and others. More recently, it has been used to study behaviours related to internet and technology. Pavlou and Fygenson (2006) used the theory to study the adoption of e-commerce and validated the predictive power of the Theory of Planned Behaviour. Multiple authors have studied the adoption of internet banking in different countries using the TPB (S. Chan & Lu, 2004; Nasri & Charfeddine, 2012; Shih & Fang, 2004). Carsrud & Brännback (2009) and Krueger & Carsrud (1993) demonstrated robustness of the Theory of Planned Behaviour in understanding and explaining entrepreneurial intentions and behaviour.

Wide applicability of the TPB in different contexts has led to a substantial stream of research support for the theory (Sideridis et al., 1998). TPB is widely considered to be easy to understand and also parsimonious. Parsimony is important because the strength and utility of the theory is many a times associated with its simplicity (Reynolds, 1971 as cited by Knabe, 2012). Chang (1998)
when comparing the TPB to TRA asserted that the former was superior in studying the intention to perform unethical behaviour. Armitage and Conner (2001) in their review of 185 independent studies found that TPB helped in accounting variance in intention and behaviour. The study also revealed that a significant portion of variance was explained by the PBC concept exclusive of the constructs (Subjective Norms, Attitude) common to TRA & TPB (Armitage & Conner, 2001).

TPB relies on self-reports, much like other decision-making models, despite there being research to suggest that individuals may portray socially desirable attitudes and intentions in such reports (Armitage & Conner, 2001). For example, Hessing et al. (1988) in their study on evasion of tax found that objective behavioural measures were more reliable than self-reporting of behaviour. Another common criticism of TPB has been its failure to incorporate the influence of past behaviour. Conner & Armitage (1998) found that such past behaviour could account up to 13% of variance in behaviour. Since the model is based on rational decision making theories, it has been also criticised for not taking into account the affective processes that can introduce bias in human judgements and behaviour (Conner & Armitage, 1998; Gibbons et al., 1998).

2.3.2. Norm Activation Model

Schwartz's (1977) Norm Activation Model (NAM) focuses explicitly on the normative and moral dimensions in human behaviour, and was created with the motivation of providing a framework for understanding pro-social, altruistic behaviours. It suggests that moral behaviours emerge as a result of personal norms (PN) that arise from two components: one’s awareness of the consequences (AC) of her/his actions, and one’s ability and willingness to assume responsibility (AR) for those consequences. Hence, these individuals are aware of adverse consequences of an action (or non-action) and comply with ascription of responsibility to the self by acknowledging that their actions might avert those consequences. Two different interpretation of the NAM exist in the literature as seen in Figure 4 and Figure 5. Some scholars (see Black et al., 1985) suggest that AC affects AR which is an antecedent to PN, and finally PN influences behaviour, whereas others (see Schwartz & Howard, 1980) postulate that AC and AR influence the effect of personal norms on the behaviour.

Personal Norms

Personal norms represent the individual’s view about right and wrong (Arvola et al., 2008). The main difference between this variable and ‘subjective norms’ is that the consequences of either
following or not following personal norms is based on one’s self concept, unlike social norms where it is tied to the perceived social concept (Arvola et al., 2008).

Figure 4 NAM Mediating Model, adapted from Groot (2008)

Awareness of Consequences (AC) → Ascription of Responsibility (AR) → Personal Norms (PN) → Behaviour/Intentions

Figure 5 NAM Moderating Model, adapted from Groot (2008)

Awareness of Consequences (AC) → Ascription of Responsibility (AR) → Behaviour/Intentions

Personal Norms (PN)

Awareness of Consequences

Ascription of Responsibility

Personal Norms

Behaviour/Intentions

Awareness of Consequences

It is also sometimes referred negatively as the awareness towards the negative consequences when not acting on a moral behaviour (Schwartz, 1977a).

Ascription of Responsibility

Ascription of Responsibility (AR) in this case refers to the acceptance of the personal responsibility for the consequences (Zur, 2012). It is sometimes depicted as a feeling of responsibility for not acting in a prosocial manner which led to the negative consequences.

Review

The NAM has been successful in predicting a wide variety of prosocial behaviours like donating one’s bone marrow (Schwartz, 1970) or blood (Zuckerman & Reis, 1978), performing some form of volunteering work (Schwartz, 1974), and others. In the context of environment, NAM has been used to explain energy conservation habits (Osterhus, 1997), recycling (Bratt, 1999), and willingness to pay for environmental protection (Guagnano, 2001).
Though widely applied, NAM has received its fair share of criticism. Though it is apparent that values are important for explaining behaviour, NAM does not specify which or what values are to be considered when studying prosocial behaviour (Groot, 2008; Zur, 2012). The relationships between the factors (i.e., AC, AR and PN) is unclear (see, Ruyter & Wetzels, 2000) as explained in earlier section with the two different interpretations. Along with this, there is confusion in terms of the definition for the construct of ascription of responsibility. Schwartz (1977) among others defines this construct as the “responsibility for the consequences of the problem”. Other scholars like Montada and Kals (2000), consider AR as the extent to which an individual can make contribution to problem’s solution. Stern (2000b) suggests that the role of personal norms is exaggerated and it may not be as important as the role ascribed to it in NAM.

**2.3.3. Conclusion**

The first difference between the Theory of Planned Behaviour and Norm Activation Model is that while TPB stresses personal utility and the individual’s cost versus benefit analysis (Ajzen, 1991), NAM emphasizes on altruism (Schwartz, 1977b). The second difference is that in NAM the intention construct is not separated from the actual behaviour. Finally, NAM focuses on internal norms (personal norms) while TPB focuses on external norms (subjective norm). The TPB assumes that when an individual is confronted with choice between two behavioural alternatives, the one that is associated with most positive behavioural consequences will be chosen (Ajzen, 1991).

Several studies have extended the TPB with NAM variables, the personal norm concept in particular for investigating behaviour for which moral considerations are likely to exist (Abrahamse & Steg, 2009a; Huijts et al., 2012; Huijts et al., 2014; Parker et al., 1995). This has been mainly because most cases for social behaviours are best seen as a combination of self-interest and prosocial motives (Parkin, 2012). Personal norms have been found to significantly add to the explanation of the TPB for a range of environmentally-relevant behaviours (like using energy-saving bulbs, reducing meat consumption, car usage for short distances; Harland et al., 1999). In other domains, too, personal norms appear to have an influence on behaviour or behavioural intention, in addition to the TPB or TRA like predicting dishonest behaviour (Beck & Ajzen, 1991). Inclusion of personal norm measure can potentially increase the explained variance in the intention by 10% to 15% (Parker et al., 1995).
According to Harland et al. (1999), although these studies support the expectation that adding a measure of personal norm to the TPB can enlarge our understanding of the determinants of intentions or behaviours, the range of behaviours for which this applies is not clear. According to them an since no objective criterion is available, the question of whether or not the addition of personal norm to the TPB constructs increases understanding of environmentally relevant behaviour is an empirical one (Harland et al., 1999).

This research is focused on the acceptance of smart HEMS. So, the behaviour in discussion is to buy the smart HEMS. Due to time constraints, a longitudinal study cannot be conducted and hence the research only focuses on the intention to buy. NAM variables are incorporated with TPB so as to increase the predictive power of the entire model. But not all NAM variables are included because research indicates that awareness of consequences may not significantly add to the explanation of intention (Heath & Gifford, 2002). The resulting base theoretical model can be seen in Figure 6.

![Figure 6 Base Theoretical Model](image)

### 2.4. Values in Technology

Values and their definitions have long been a topic for research. Various authors have provided definitions for values depending on their field of research. Social researchers like Rokeach and Milton (1973) conceptualise values as goals or ideals that are instrumental in defining what things are important to people and what are the consequences in their lives that they strive for. On similar terms, Schwartz (1992) defines values as trans-situational goals of varying importance that are desirable and help as principles for guiding the life of an individual or a social entity. In the field
of Ethics of Technology, Poel and Royakkers (2011) note that “values are lasting convictions or matters that people feel should be strived for in general and not just for themselves to be able to lead a good life or to realize a just society”. Regardless, all these definitions agree on the part that values conceptualise something that is important to the individual and thus can affect the behaviour of the individual. Values in this research are defined as important principles or convictions that the individual strives for that have important implications on both behaviour and personal well-being.

Though technological innovations are designed with obvious purpose of serving certain function, they often implicate human values (Friedman & Kahn, 2003). Friedman and Kahn (2003) argue that once a technology gets hold in the society, then it becomes very difficult to override the values driven by technology. They describe three positions to explain how values are implicated in technology. Embodied position holds that the designers and developers of the technology often inscribe their own values and intentions in the technology. This technology, then, determines specific kind of human behaviour. This position is also referred to as technological determinism (Smith & Marx, 1994, as referenced by Friedman & Kahn, 2003). Exogenous position on the other hand holds that external societal forces (like, economics, race, politics, etc.) often determines how a certain technology is used. Interactional position argues that though the features designed in the technology support certain values or hinder others, the use of the technology often depends on the goals of the person interacting with it. Depending on the value or intention that a technology embodies, it may never take hold in the society (Friedman & Kahn, 2003).

### 2.5. Ethical Values relevant for HEMS

Ethics refers to a set of principles that provide a guideline to right, good, and proper behaviour (Josephson Institute of Ethics, 2015). They don’t always provide with a course of action which is “moral” but help in deciding between competing positions. Ethical values thus often require that we stretch our own interests to protect, serve, help and respect others. These values help the individual to establish a compass in terms of what are “right” things to do and the things “worth” doing (Jansen & Glinow, 1985). Not all the values that are part of an individual’s value system can be considered as ethical values. Values like efficiency lack ethical component. Ethical values often involve the qualities of self (like honesty) or ethical behaviour towards the environment and society (like fairness).
Ethical considerations no longer stand apart while designing information technology systems due to their profound and ever increasing impact on the human lives (Friedman & Kahn, 2003). Various approaches have been discussed in the literature like Value Sensitive Design, Computer Ethics, etc. to study values, ethics and design. Discussion on this concepts is beyond the scope of this research, as the concentration of this research is on how these ethical values embodied affect the acceptance of systems. For this we next discuss the ethical values most relevant to the topic of this research.

2.5.1. Privacy

Probably the most cited and researched in case of ICT systems, privacy is a value with ethical import according to Friedman and Kahn (2003). As computer and ICT systems advance and are able to gather and process information about specific individuals, the discussion on privacy has intensified. Schoeman (1984) refers to privacy as individual’s right or entitlement to determine what information about oneself can be communicated to the other person. This is just one aspect of privacy, with the others being right to be left alone, freedom from intrusion and the right to not be tracked, followed, or watched (in one’s own private space) (Warnier et al., 2015).

There is, however, another related aspect of privacy which is more critical to this research and that deals with the perception of people with respect to potentially privacy invading technologies, their use and in how far “privacy” addresses their ethical concerns. This research focuses more on this aspect. Often people are not so much concerned with “privacy” in the sense of being left alone but want to be protected from harm or unfair treatment (Warnier et al., 2015). In this view, people are not primarily concerned about their privacy when they use a system but rather are concerned about what is done with their personal data, which could harm or discriminate them (Warnier et al., 2015). This concern can have an impact on how the individuals view the technology and indeed this is seen in the research. All the authors discussed in the section of social acceptance of smart energy systems identify privacy as the most important factor for acceptance of such technologies. For e.g. Verbong et al. (2013) states that privacy has the potential to block the successful introduction of smart grid and demand side management.

2.5.2. Trust

Friedman and Kahn (2003) in their article “Human values, ethics and design” identify trust as one of the 12 values with ethical import. Schneider (1999) uses the term “trust” or “trustworthy” for a
system whose performance along the dimensions of safety, reliability and security is as expected. This definition which equates “trust” with just performance of machine misconstrues the fundamental characteristic of the value. By and large, it is agreed by most philosophers and social scientists that trust is willing and voluntary and is showcased in presence of uncertainty (Nickel, 2015). Rousseau et al. (1998) defined trust as a state where in the individual accepts the vulnerability when he has positive expectations from the behaviour of others. This is termed as a “three-state trust” where one entity trusts another entity to promote its interests (Baier, 1986).

Trust in stakeholders that are responsible for the technology can generally increase acceptance as it can affect the perception of risk and benefits (Siegrist, 2008; Siegrist & Cvetkovich, 2000). In cases where the people have little knowledge of technology, acceptance may hinge upon the trust on actors (Huijts et al., 2012; Midden & Huijts, 2009). In this research, we will focus on whether individuals trust the companies providing Smart HEMS.

2.5.3. Autonomy

Autonomy is another human value with ethical import as described by Friedman and Kahn (2003). People value their autonomy in a sense that they decide, plan and then act in such a manner that will help in achieving their goals. Friedman and Kahn (2003) believe that people should be given autonomy over technology as much as possible. In the context of this research the goals of the people can be saving electricity, cost effectiveness achieving efficiency or acting sustainably and responsibly. Autonomy, here, refers to user’s control over the Smart HEMS technology in order to plan and execute their plan in a way to achieve their aforementioned goals.

With the recent advance of ambient intelligent systems, which sense the user and context and sometimes act on behalf of the user, user autonomy is a value at risk (Hultgren, 2015). This can be seen in the smart HEMS technologies which automate their operations like scheduling the operations timing of appliances).

2.5.4. Fairness

The idea of fairness has been consistently linked with ethics and is widely considered as an ethical principle (Velasquez et al., 1990). Evaluation of a technology or implementation of a policy by people is influenced by two forms of fairness. First is the procedural fairness which refers to the idea of fairness in the processes that lead to the implementation. The other one is the distribution
fairness which is concerned with the fairness in allocation of outcomes of the implementation (risks or benefits). Both of these can affect the attitude and can play an important role in acceptance of risky technologies (Huijts et al., 2012). In this case however, unlike installation of nuclear plant or constructing a hydrogen refuelling station, procedural fairness doesn’t play a role. Distributive fairness can however play a role, as entire society benefits from the installation of a smart HEMS but only the individual who has installed the system is affected by the risks (privacy, cost, etc.)

2.5.5. Sustainability

Friedman and Kahn (2003) include sustainability as one of the 12 human values with ethical import. Environment sustainability means to interact with the environment in a responsible manner so as to reduce the depletion of naturally occurring resources. Brundtland (1987) defines sustainability as the “development that meets the needs of the present without compromising the ability of future generations to meet their own needs”. This implies “intergenerational equity” i.e., the notion that our children and grandchildren must have the same quality of our environment as we have and also “intra-generational equity,” i.e., the equity within our own generation related to the poor countries of our world (Gosseries, 2008; Wever & Vogtlander, 2015).

There are two aspects of sustainability when it comes to technologies like Smart HEMS. First is whether the technology itself is produced in a sustainable manner (using environmentally friendly and/ or conflict free materials, etc.). Second aspect is that HEMS enables effective and efficient utilisation of energy thereby reducing our dependence on traditional energy sources.

2.6. Technological Characteristics

2.6.1. Compatibility

Compatibility refers to fit between interrelated entities so that they can function together (Vries & Egyedi, 2007). A compatible device is capable of exchanging data with equivalent and horizontal objects and also capable of working with older devices (Erlinghagen et al., 2015). Smart Home Energy Management Systems must be compatible with existing (or older) appliances available in the market or at consumer’s residence. Kaufmann et al. (2013) in the evaluation of smart meters requirement determined that compatibility played an important role for technology minded end users. Kizhakenath (2016) also identified compatibility as a factor for market and social acceptance of smart meters.
2.6.2. Feedback

Feedback in this context refers to the output of the HEMS which can be used as a basis for improvement. Feedback refers to providing data related to the usage of energy at a residential location. This feedback can be provided directly (collected data displayed real time) or indirectly (after post processing task is performed on data). Darby (2006) claims that providing feedback on energy usage to users can actually help in increasing electricity savings by up to 30%. Gerpott & Paukert (2013) believed that effective consumption feedback can increase a customer’s willingness to pay for smart technology. Paetz et al. (2012) found that feedback (direct or indirect) can act as a motivator for acceptance. AlAbdulkarim et al. (2014) and Kizhakenath (2016) both included feedback as a construct in their models for acceptance of smart meters.

2.7. Demographic Characteristics

2.7.1. Age

Role of age in ethical decision making has been a mixed bag. Browning & Zabriskie (1983) found that young people were more inclined towards ethical decision making while Ruegger & King (1992) and Serwinek (1992) concluded that the opposite was true. On the other hand, Callan (1992) & Izraeli (1988) found no significant relationship between age and ethical decision making. Wiernik et al. (2013) in a meta-analysis studied the strength and direction of age-effect observed in environmental studies. They found that the relationship between age & environmental values, awareness, motives & behaviour was small or even bordering negligible in 214 studies. However they emphasised that even if the effect was of small magnitude, it was important and interesting to study this effect. Morris & Venkatesh (2000) found that clear differences existed with age in technology adoption and discovered that younger people were more inclined towards usage than old. Chen & Sintov (2016) also found that younger respondents were significantly likely to adopt smart HEMS.

2.7.2. Education

Type and length of education plays a significant role in ethical decision making. Beltramini et al. (1984) and Hawkins & Cocanougher (1972) found that business graduates are more inclined to make ethical decisions than non-business graduates. A similar result was found by Chonko & Hunt (1985) in the form that people with technical degrees were more ethical than non-technical degree.
In Technology adoption literature, education has been known to play a significant role. Burton-Jones & Hubona (2006) found that education may not only have an effect on subjective norms (perceived case of use) but also may directly affect usage. Mathieson et al. (2001) argued that education could reflect the user’s internal capabilities and thus affect his attitude towards the technology.

2.7.3. Gender

Various studies in the ethical decision making literature have found that gender plays a role with women more inclined towards ethical decision making than men (Beltramini et al., 1984; Ferrell & Skinner, 1988; Ruegger & King, 1992; Whipple & Swords, 1992). Role of gender has also been widely studied in the technology adoption literature. Research has shown that decision making processes by women and men are different (Gefen & Straub, 1997; Meyers-Levy & Maheswaran, 1991; Venkatesh, Morris, & Ackerman, 2000).

2.7.4. Housing Condition

Intention to buy the smart HEMS technology may depend on housing condition of the respondent. If you own a house/apartment, you might have a stronger intention to buy. Also, staying in a rented house/apartment can have an effect on perceived behavioral control, as the respondent may not have the decision making capability to install the systems.

2.8. Knowledge

Knowledge related to the operation of technology, its effects in terms of advantages and disadvantages can greatly influence the people’s perception & attitude towards technologies and hence indirectly affect he acceptance of technologies. Molin (2005) found that people with more knowledge about the usage of hydrogen as a fuel perceived less security risks about the technology and resulted in a positive attitude towards technologies.

2.9. Acceptance of Smart Energy Technologies

A lot of acceptance research has been done around smart meter which is component of the smart HEMS. The chief reason behind this is the fact that smart meters have been a controversial topic in all the countries it has been implemented. Kranz et al. (2010; Germany), Toft et al. (2014;
Denmark, Norway and Switzerland) and Chou et al. (2015; Taiwan, Korea, Indonesia, and Vietnam), all used some form of modified Technology Acceptance Model (TAM) to explain the acceptance of smart meters in various countries. All of these researches concluded that consumer perceptions of perceived ease of use and perceived usefulness can affect the consumer acceptance of smart meters. Kranz et al. (2010) believed that incorporating factors like social influence and self-efficacy could provide further insights. Toft et al. (2014) concluded that personal norms can play an important role in acceptance of technologies. An interesting point to note here is that though all these models use similar models, the variance explained by models is depended on the nationality of the individuals.

AlAbdulkarim et al. (2014) and Kizhakenath (2016) both studied the acceptance of smart meter albeit from different perspectives. While Kizhakenath (2016) utilised the dimensions of Responsible Innovation and Value-Sensitive Design, AlAbdulkarim et al. (2014) utilised the constructs from the Unified Theory of Acceptance and Usage of Technology (UTAUT) and Innovation Diffusion Theory (IDT). Both the models included additional determinants specific to the Dutch context. Both of these models placed privacy and cost (perceived cost; cost-effectiveness) as important to the socio-political and community acceptance. The model built by AlAbdulkarim et al. (2014) though very comprehensive relies solely on the technological characteristics and rational decision making.

Paetz et al. (2012) conducted an experimental study on user acceptance of smart home technologies for shifting electricity demand. Chen and Sintov (2016) investigated willingness to adopt a variety of smart-grid enabled home energy management technologies and programs in California. While Chen and Sintov (2016) claimed that affiliation with nature was the strongest predictor of intentions, Paetz et al. (2012) found effective feedback from the technologies along with dynamic pricing as the motivators for acceptance. In a different kind of study, Gerpott and Paukert (2013) also determined that consumption feedback is an important predictor for explaining German consumer’s willingness to pay (WTP) for smart meters along with Expected Savings, Intention to change usage behaviour, Trust in data protection and Environmental Awareness. Gerpott and Paukert (2013) also believed that including individual characteristics and perception dimensions may further increase the explained variance.

Buchanan et al. (2016) examined the perceptions of the public with regards to the smart metering initiative of the British Government using focus groups while Balta-Ozkan et al. (2013) focused
on determining the social barriers towards accepting smart home technology through an analysis of expert interviews and attitude of the residents. Both of these researches concluded that loss of control, privacy and security, cost, and trust can play an important role in determining the acceptance of these technologies. A distinction in the results in both these technologies was the fact that British public was much more accommodating of automation (and hence loss of control) than compared to the study by Balta-Ozkan et al. (2013).
3. Theoretical Model

3.1. Model Overview

As discussed in Section 2.3.3, constructs from NAM theory are combined with the constructs of TPB, to create a more comprehensive model to explain intentions (to buy Smart HEMS). At the end of the last chapter, a theoretical background on the 5 ethical values (Privacy, Trust, Autonomy, Fairness, and Sustainability) that are relevant to this research was provided. In this chapter, discussion revolves around how these values and other identified technological characteristics (Compatibility and Feedback) fit within the model and how they affect other constructs of the model.

The model used for this research is shown in the Figure 7.
3.2. Ethical Values

3.2.1. Privacy

Some authors have studied the direct effect of privacy on intention to buy while others have concentrated on the effect of privacy on intention through attitude. The findings from these studies are mixed due to difference in the research models, but wherever a direct effect on intention of privacy was hypothesised, the authors found no support towards such a relationship (Jarvenpaa & Todd, 1996, 1997; Khalifa & Limayem, 2003; Limayem et al., 2000). According to George (2004), a direct relationship between privacy concerns and actual online purchasing behaviour is tenuous at best. Similarly, Miyazaki and Fernandez (2001) found no relationship between privacy concerns and Internet purchasing behaviour. On the other hand, there is support for a hypothesized relationship between privacy and attitudes (George, 2002; Jarvenpaa & Todd, 1996, 1997). George (2002) posited that the relationship between privacy and behavioural intention is more complex, and that it is mediated by the attitude towards the behaviour. They found that beliefs favouring privacy led to negative attitude and this negative attitude was associated with lower levels of intentions towards purchasing.

H1 – Lack of privacy negatively affects the attitude towards technology.

3.2.2. Trust

Rousseau et al. (1998) defined trust as a state where in the individual accepts the vulnerability when he has positive expectations from the behaviour of others. Thus, trust enables favourable expectations that no harmful outcomes will occur if a trustor undertakes a behaviour (Pavlou & Fygenson, 2006). Trust creates favorable perceptions about the outcomes of the vendor's actions, thus creating positive attitudes. Thereby, trust is proposed as an antecedent to the attitude towards behaviour in literature. George (2002) measured trustworthiness and found that positive beliefs about trustworthiness were related to positive attitudes toward purchasing. Suh and Han (2003) found trust was statistically significantly related to attitudes toward using e-commerce. Pavlou (2002), using a TPB model, found that trust in an online retailer was statistically significantly correlated with attitudes toward purchasing. Jarvenpaa et al. (2000) and Pavlou (2003) also found that trust has an impact on intentions by creating positive attitudes.
H2 – Trust of consumers in the supplier will lead to a positive attitude towards the technology.

3.2.3. Autonomy

Friedman and Kahn (2003) believe that people should be given autonomy over technology however, the recent advancement of ambient intelligent systems, which sense the user and context and sometimes act on behalf of the user, user autonomy is a value at risk (Huldtgren, 2015). This can be seen in the smart HEMS technologies which automate their operations like scheduling the operations timing of appliances). This lack of autonomy may be evaluated negatively by the consumers and thus they may form a negative attitude towards it and affect the acceptance of smart energy technologies (Balta-Ozkan et al., 2013; Buchanan et al., 2016).

H3 - Loss of control will have a negative effect on the attitude.

3.2.4. Fairness

Perceived fairness in the distribution of costs, risks, and benefits resulting from specific implementation and use of technology can affect the intention to use. Increased feelings for perceived fairness will lead to increased acceptance of technology and thus implies higher intention to use (Huijts et al., 2012). Schuitema et al. (2011) while studying acceptability of transport pricing policies were able to determine that distributive justice predicted the attitudes towards these policies. As cited by Huijts et al. (2012), Eriksson et al. (2006) and Jakobsson et al. (2000) albeit using a general fairness term (instead of procedural and distributive classification) modelled it as a predictor of attitudes towards travel demand management. Following this, it is assumed in this research that distributive fairness is an antecedent to attitude and indirectly affects intention to buy/use.

H4 – Higher perceived fairness will lead to a positive attitude towards technology.

3.2.5. Sustainability

In this research, the aspect of sustainability that is focused on is the ability of the system to allow for effective and efficient utilisation of energy. This can have an impact on the attitude of the individual towards the technology. An attitude favouring environmental sustainability has been
demonstrated to have positive effects on the intention to buy green products (Chan & Lau, 2002), recycle wastepaper (Cheung et al., 1999), and reduce household garbage (Taylor & Todd, 1995).  

**H5 – Higher perceived sustainability will lead to positive attitude towards technology.**

### 3.3. Technological Characteristics

#### 3.3.1. Compatibility

As discussed before, compatibility refers to fit between interrelated entities so that they can function together. According to Taylor & Todd (1995b), as the compatibility of the system increases, the attitude towards the information system also becomes more positive. Such an outcome, according to them is consistent with the literature relating to diffusion of innovation and with results from the information system usage studies. Following this, Ajjan & Hartshorne (2008) used compatibility as an antecedent to attitude to study the behaviour to adopt Web 2.0 technologies. Moons & Pelsmacker (2015) also found that perceived compatibility can have significant effect on the attitude towards the electric car. In this research, based on literature, compatibility is conceived as an antecedent to attitude towards technology.

**H6 - Higher compatibility with lifestyle and appliances will lead to a positive attitude towards technology.**

#### 3.3.2. Feedback

Feedback in this context refers to providing data related to the usage of energy directly (collected data displayed real time) or indirectly (after post processing task is performed on data) to the user which can then be used as a basis for improvement. The feedback from the system can reinforce the positive attitude towards the technology and thus, promotes the use of the technology (Gerpott & Paukert; 2013). Froehlich et al. (2010) in their survey of Eco-feedback technology, technology that provides feedback on individual or group behaviours with a goal of reducing environmental impact, found that feedback on electricity consumption affects the attitude towards technology and can lead to increased energy savings of between 5 and 12%. Based on this, it is assumed that feedback affects the intention to buy/ use technology through attitude.

**H7 - Effective feedback on energy consumption can lead to positive attitude towards technology.**
3.4. Behavioural Model

3.4.1. Responsibility

Responsibility in this case is depicted as feelings for acting in a prosocial manner which may lead to positive consequences. This activates a personal norm that determines whether one should perform a particular action that prevents a harmful outcome (De Groot & Steg, 2009).

*H8 – Stronger feelings of responsibility would lead to stronger personal norms (obligation to perform a behaviour).*

3.4.2. Attitude

An individual’s attitude towards the behaviour is determined by beliefs which lie beneath the individual’s attitude towards a given behaviour and are termed as *behavioural beliefs*. These beliefs are concerned with the outcomes or evaluation of the outcomes of the behaviour. A belief that adopting behaviour will lead to positive outcomes will result in higher intention to perform the behaviour (Ajzen & Fishbein, 1969, 1980; Ajzen, 1991).

*H9 – Positive attitude towards smart HEMS would lead to higher intention to buy.*

3.4.3. Subjective Norm

Subjective norm refers to the perception of individual regarding the societal pressures to perform (or not perform) the behaviour under consideration. Subjective norms of individual are derived from the fact whether referents important to the individual approve or disapprove of the behaviour and the motivation of the individual to comply with these referents. Thus, a positive subjective norm results from important referent believing that certain behaviour should be performed and high motivation of the individual to comply with the referent.

*H10 – Subjective norms positively influence intention to buy.*

3.4.4. Perceived Behavioural Control

Perceived Behavioural Control (PBC) is the extent to which the individual believes that he/she can perform the behaviour under consideration. If the individuals perceive that they have more opportunities and resources, and that there are fewer obstacles, then their perceived behavioural control is higher.

*H11 – Higher perceived behavioural control leads to stronger intentions to buy.*
3.4.5. Personal Norm

Personal norms is referred to as feeling a moral obligation to perform or refrain from specific actions (Schwartz & Howard, 1980).

**H12** – *Stronger personal norms lead to higher intentions to buy.*

3.5. Knowledge

In the technology acceptance framework developed by Huijts et al. (2012), knowledge/experience can have a direct effect on various variables in their model. In this research, it is predicted that knowledge about the system can help the respondent to form an attitude towards the system and even directly affect intentions to buy.

**H14** – *Knowledge about the system can have significant effect on the attitude and intention to buy.*

3.6. Demographic Characteristics

In section 2.5.2, four characteristics of the individual which include age, gender, housing condition, and education level that may affect the intention to use the technology. Education not only affects the attitude of an individual (Mathieson et al., 2001) but it also has an effect on subjective norms and may also directly affect usage (Burton-Jones & Hubona 2006). Gender not only plays an important role in ethical decision making as discussed earlier, Conner et al. (2003) also found that males feel more normative pressure (subjective norm), perceive lesser control and moral norms in their study on intention to break speed limit. Thus, the demographic characteristics have an effect multiple variables in the developed model, especially the antecedents of intention.

**H13** – *Age, Gender, Education, and Housing Condition can have significant effect on the attitude, subjective norms, perceived behavioural control, personal norms and intention to buy.*
4. Methodology

For determining the validity of the model and to determine the relative influence of ethical values on intentions to buy, the required data would be collected from respondents using a survey.

4.1. Survey

Survey is more suited when studying attitude because it can elicit more information from the respondents than through observational studies (Glasow, 2005; McIntyre, 2002). In “Fundamentals of Survey Methodology”, Glasow (2005) suggests that the conceptual model consisting of dependent and independent variables can be used to define the scope of the survey. Thus, a theoretical model was developed detailing the relationships between various variables that needed to be studied which formed the basis for the survey questionnaire development. The questionnaire that was developed for the study is included in Appendix 3.

4.1.1. Survey Design

This research uses TACT principle i.e. Target, Action, Context and Time to identify the target behaviour. The behaviour is to study the acceptance (action) of smart energy systems (context) by potential (time) users (target). Thus, the target audience of this survey (potential) users in order to measure their intention to use.

Salant & Dillman (1994) note that the choice of survey medium depends on the availability of the resources. Electronic questionnaires were decided to be the designed medium of the survey as they are efficient in reaching wide geographical regions, are inexpensive, easy to administer and provide easy convenience to the respondents. However, in the latter stage of data collection to increase the participation of a respondents with higher age paper-based surveys were also administered.

4.1.2. Survey Execution

Due to time and monetary limitations of this study, a convenience sampling was used for collection of data. Convenience sampling is a non-probabilistic sampling technique where the survey respondents are selected due to their easy accessibility and proximity to the researcher.
**Sampling**

As discussed, a convenience sample is being used where the units (potential user/buyer) that are selected for inclusion in the sample are the easiest to access. An electronic survey hosted on www.typeform.com was used for data collection. The units included in the sample were from the network of the researcher and were invited to fill up the survey using multiple social networking websites (Facebook, LinkedIn, Gmail, WhatsApp, etc.). This set of group included mainly students or former students of TU Delft and other members of the researchers social circle. After the first round of data collection, it was found that the respondents were predominantly young. To correct this, written questionnaire were also distributed among the colleagues of the researcher at place of researcher’s internship.

**Survey Execution**

There are two ethical considerations that are important when it comes to surveys and collected data. The first consideration is that the survey responses must be kept confidential at an individual level and the results must be reported at an aggregate level. Second consideration to keep in mind is that the participation in survey is voluntary and must not be forced upon the respondents. Both of these considerations are strictly applied to this research.

Based on the model developed in Section 3, a survey was developed using measures for each variables as used in the literature. These measures are described in detail in next Section 4.2. The initial survey which was developed had 54 questions. According to the suggestions of Levy and Lemeshow (2013) and Glasow (2005), a pilot survey was carried out so as to test the survey questionnaire to determine if the respondents understand the survey questions & responses correctly. This survey was then administered to 10 individuals (4 Dutch, 3 Indians, 1 Italian, and 1 French; 3 were 18-25 years, 5 of 26-34 years; 2 of 35-44 years) for feedback on the survey.

Based on the feedback as received from the pilot survey the survey size was reduced to 46 questions as some questions were deemed to be too similar by the respondents (e.g. I have confidence in the HEMS supplier and I have trust in HEMS supplier). Additional explanation was added to the question for distributive justice as most of the respondents felt the question was difficult to understand. An introduction to the Smart HEMS was provided at the beginning of the survey to provide some background to the respondents. The final survey questionnaire is as shown in Appendix B.
4.2. Measures

After the survey had been already administered, it was found that some of the developed measures didn’t really measure the concepts they were operationalised for or that they were too evaluative in nature. For that reason, some of the measures from the questionnaire were dropped and not considered for analysis. This section describes only the measures that were used for analysis.

4.2.1. Knowledge

FAM1 - How familiar are you with Smart HEMS technology or its components?

4.2.2. Compatibility

In this research, compatibility refers two things. One compatibility refers to the compatibility of the smart HEMS technology with the existing appliances in the house while the other one refers to the compatibility of the technology with one’s lifestyle. For measuring compatibility, following measurements have been used based on Atkinson (2007), Taylor & Todd (1995b), and Moore & Benbasat (1991).

COM1 - I believe using Smart HEMS would fit my lifestyle.
COM2 - I believe that Smart HEMS should be compatible with existing appliances in my house.

4.2.3. Feedback

Feedback in this context refers to the output of the HEMS which can be used as a basis for improvement. Based on Gerpott & Paukert (2013), usefulness of feedback was operationalised using following measurement items.

FED1 – Smart HEMS should transfer consumption reports automatically to my computer/ laptop/ mobile
FED2 – Smart HEMS should be able to forecast my consumption for coming months.
FED3 – Smart HEMS should be able provide feedback on individual domestic appliances.
4.2.4. Autonomy

Autonomy, here, refers to user’s control over the Smart HEMS technology in order to plan and execute their plan in a way to achieve their aforementioned goals. Krishnamurti et al. (2012) was used for conceptualising autonomy/ lack of control.

AUT1 – I believe using smart HEMS would allow energy companies to control my electricity use.
AUT2 – I believe Smart HEMS can control my appliance usage.

4.2.5. Privacy

The aspect of privacy which is more critical to this research the one that deals with the perception of people with respect to potentially privacy invading technologies, their use and in how far “privacy” addresses their ethical concerns. Using Chou & Yutami (2014) following items have been developed for the measurement of privacy.

PRI1 – I believe that all my personal information will be protected.
PRI2 – I believe that all my data on energy consumption will be protected.
PRI3 – I believe that Smart HEMS can violate my privacy.

4.2.6. Trust

Trust, in context of this research, is measured as the extent of faith in the industry. Based on Cannière et al. (2009) and Huijts et al. (2014) the following items have been used for measurement of trust.

TRU1 – I trust the companies providing the Smart HEMS technology.

4.2.7. Distributive Fairness

Distributive fairness is concerned with the fairness in allocation of outcomes of the implementation (risks or benefits) of a project or technology. Based on Huijts et al. (2014), following measure was used for distributive fairness.

If you buy the smart HEMS, what do you think of the distribution of benefits and drawbacks with respect to yourself and others?

DIF1 – Unfair <-> Fair
4.2.8. Sustainability

The sustainability aspect in consideration for this research is that HEMS enables effective and efficient utilisation of energy thereby reducing our dependence on traditional energy sources. Following the conceptualisations by Annunziata & Vecchio (2016) and Cirnu & Kuralt (2013), sustainability is measured using following items.

SUS1 – I believe that using Smart HEMS contributes to sustainability
SUS2 – I believe that using Smart HEMS will contribute in protecting the environment.

4.2.9. Attitude

Francis et al. (2004) describe two methods for measuring attitudes, (1) Direct measurement of attitude and (2) Indirect measurement. Direct measurement involves the use of two extreme adjectives which are evaluative (e.g. agree – disagree). Indirect measurement involves first identifying the target population’s behavioural beliefs and then designing a survey to measure these beliefs and their outcomes. This research utilises the direct measurement approach applied for which the following measures have been developed on the basis of George (2004).

ATT1 – I think buying Smart HEMS is a good idea
ATT2 – In my opinion, it is desirable to buy Smart HEMS

4.2.10. Subjective Norms

Francis et al. (2004) define two methods for measuring Subjective Norms (SN). Direct method of measurement involves direct questions with reference to the opinions of important people. The indirect measurement involves identifying important referent group and then assessing the individual’s motivation to comply. This research adopts the direct measurement of Subjective Norms for which following measures are used based on Venkatesh et al (2012), Chou & Yutami (2014), and Bhattacherjee (2000).

SUN1 - People who are important to me think that I should buy Smart HEMS.
SUN2 - People whose opinions that I value prefer that I buy Smart HEMS.
4.2.11. **Perceived Behavioural Control**

Perceived Behavioural Control can be measured directly by measuring how difficult it is for the person to perform the behaviour, how confident they are about performing it, whether performing the behaviour is up to them and finally how strongly factors beyond their control can determine their behaviour (Francis et al., 2004). Much like attitude, Perceived Behavioural Control can also be measured indirectly by replacing the behavioural beliefs by a set of control beliefs. Once the control beliefs are identified, questionnaire items can be used to assess the strength of these beliefs and power to influence behaviour. Like attitude, this research opts for a direct measurement of Perceived Behavioural Control. Following measures have been designed using Francis et al. (2004) and Cannière et al. (2009).

PBC1 – I would find it difficult to buy a Smart HEMS
PBC2 – The decision to buy a Smart HEMS is beyond my control.
PBC3 – I have the resources to buy a Smart HEMS

4.2.12. **Responsibility**

Responsibility in this case is depicted as feeling for acting/not acting in a prosocial manner which may lead to positive/negative consequences. Based on the articles of Steg & Groot (2010) and Abrahamse & Steg (2009), the following measures for responsibility were developed.

RES1 – I feel jointly responsible towards the exhaustion of energy resources
RES2 – I feel responsible towards the environment
RES3 – I feel responsible to do something to reduce energy usage.

4.2.13. **Personal Norms**

Personal norms represent the individual’s view about right and wrong, and therefore are sometimes called ‘moral norms’. Personal norms is referred to as feeling a moral obligation to perform or refrain from specific actions. The measures developed for measuring personal norms are based on the items developed by Steg et al. (2011) and Huijts et al. (2014).

PEN1 – I would feel guilty if I didn’t buy smart HEMS.
PEN2 – I feel a moral obligation to buy smart HEMS.
4.2.14. Intention to buy

Francis et al. (2004) conceptualise three methods to measure intentions. The first method, which they have termed as Intention performance, uses a single item (I intend to...) when actual behaviour can be measured using the same measurement scale allowing for direct comparisons. The second method, which is called Generalised Intention, uses three items for measuring intentions. The final method, Intention Simulation, develops scenarios for which the respondent must decide on his intentions. Generalised Intention would be used in this research as it offers better measurement than Intention Performance and is faster than the Intention Simulation method. Based on Venkatesh et al. (2012) and Bhattacharjee (2000) following three items have been used for measuring generalised intention in this research.

IEB1 – I expect to buy Smart HEMS
IEB2 – I want to buy Smart HEMS
IEB3 – I intend to use Smart HEMS

4.3. Data Analysis

The methods used for analysis consisted of Exploratory Factor Analysis (EFA) using IBM SPSS Statistics 23 and Structural Equation Modelling (SEM) using IBM SPSS AMOS (Analysis of Moment Structures) 23. Additionally, one way ANOVA were used. EFA was used to determine underlying relationships between measured variables. SEM was used to empirically validate the model developed in the research as shown in Section 3.1. As the model was already complicated, it was decided that instead of including demographic characteristics in SEM, one way ANOVA would be used for examining differences in dependent variables across select demographic variables of respondents (age, education, gender, and housing condition). The following sections describes these methods in details.

4.3.1. Exploratory Factor Analysis

Exploratory factor analysis (EFA) is a statistical method used to uncover the underlying structure of a relatively large set of variables (Hair et al., 2014). It serves to identify a set of latent constructs underlying a battery of measured variables (Fabrigar et al., 1999). Hair et al. (2014) provide with process for performing exploratory factor analysis which was used in this research.
Data Reduction and Sample Size Considerations

Exploratory Factor analysis can be used to achieve data reduction by (1) identifying representative variables from a much larger set of variables for use in subsequent multivariate analyses, or data summarization (2) creating an entirely new set of variables, much smaller in number, to partially or completely replace the original set of variables. Since, the aim is to perform structural equation modelling on the collected data, we will be performing data reduction. According to Hair et al. (2014), the sample must have more observations than variables and that the minimum absolute sample size should be 50 observations. Since, there are 150 responses collected by the researcher, both the conditions are met. The sample size of above 100 provides an adequate basis for the calculation of the correlations between variables.

Number of Factors

According to Hair et al. (2014; pg. 109), decision on the number of factors to be retained can be based on several considerations. According to them, (1) Factors with eigenvalues greater than 1.0 (2) A predetermined number of factors based on research objectives and/or prior research, (3) Enough factors to meet a specified percentage of variance explained, usually 60% or higher, can be used to determine the set number of factors. Based on the research model and using criterion (2), the number of factors was determined to be equal to 12. Criterion (3) was used to verify if the number of factors chosen was appropriate.

Extraction Method

Extraction is the process of reducing the number of dimensions being analysed by a set of variables into a smaller number of factors. In general, extraction of factors proceeds by first extracting the strongest factor that accounts for the most variance, and then progressively extracting successive factors that account for the most remaining variance. IBM SPSS provides with multiple methods for extracting the factors.

Principle Axis Factoring (PAF) is an extraction method which seeks to determine the least number of factors which can account for the common variance (correlation) of a set of variables. Principal axes factor (PAF) extraction is considered to be a variation of PCA (Osborne & Banjanovic, 2016). Principal Component Analysis (PCA) is a dimension-reduction method that can be used to reduce a large set of variables to a small set that still contains most of the information in the large set. It transforms a number of (possibly) correlated variables into a (smaller) number of uncorrelated variables called principal components. PAF method replaces the diagonal elements of the
correlation matrix with initial estimates of the shared variance. In PCA this substitution does not occur, effectively permitting PCA to estimate components using all of the variance and not just the shared variance.

PAF method was utilised first to conduct the Exploratory Factor Analysis on the data. However, the method failed to converge. This was due to the presence of Heywood case which occurs when there is a small sample size or when the factors do not have three indicators. With the failure of PAF, PCA was used as the extraction method.

**Rotating Factor Matrix**

Rotating the factor matrix allows to redistribute the variance from earlier factors to later ones to achieve a simpler, theoretically more meaningful factor pattern. As this research is striving for obtaining a simpler model, we will be rotating the factors. There are two kinds of rotations available orthogonal factor rotation (rotated axes are maintained at 90 degrees) and oblique factor rotation (rotated axes do not retain the 90-degree angle). Oblique rotation methods are best suited to the goal of obtaining several theoretically meaningful factors or constructs, because, realistically, few constructs in the real world are uncorrelated. Orthogonal rotation methods are the preferred method when the research goal is data reduction to either a smaller number of variables or a set of uncorrelated measures for subsequent use in other multivariate techniques. Rotation was set to PROMAX (Kappa: 4; default), a type of oblique rotation method.

**Bartlett’s Test and Measures of Sampling Adequacy**

The Bartlett test of sphericity, a statistical test for the presence of correlations among the variables, provides the statistical significance that the correlation matrix has significant correlations among at least some of the variables. Data reduction can be achieved only if the test is significant so that the null hypothesis can be rejected (null hypothesis: correlation matrix is identity matrix; no scope for dimension reduction).

Measure of Sampling Adequacy (MSA) is a measure calculated both for the entire correlation matrix and each individual variable to evaluate the appropriateness of applying factor analysis. This index ranges from 0 to 1, reaching 1 when each variable is perfectly predicted without error by the other variables. Values above .50 for either the entire matrix and each individual variable indicate appropriateness. Variables with values less than .50 should be omitted from the factor analysis one at a time, with the smallest one being omitted each time (Hair et al., 2014).
4.3.2. Structural Equation Modelling

Structural Equation Modelling (SEM) was used to empirically validate the model developed in the research. SEM is a family of modelling approaches including path modelling which enables estimation of series of linked regression equations (Bollen, 1989). A path is a causal relationship between two variables. The linked nature of the equations means that independent variable in one equation may be dependent variable in another. The total effects of a variable is thus broken down into direct and indirect effects which is in contrast with multiple regression techniques as in the case of latter indirect effects are dropped. SEM retains the indirect effects, thereby, preventing false assumption that variable has no effect on dependent variable. SEM is used in this study because it allows for, (1) Estimation of multiple and inter-related dependence relationships, (2) An ability to represent unobserved concepts/ latent variables, and (3) Defining a model to explain the entire set of relationship.

SEM models consist of observed variables (also called manifest or measured variables) and unobserved variables (also called underlying or latent variables) that can be independent (exogenous) or dependent (endogenous) in nature. Latent variables are hypothetical constructs that cannot be directly measured, and in SEM are typically represented by multiple measured variables that serve as indicators of the underlying constructs. The SEM model is an ‘a priori’ hypothesis about a pattern of linear relationships among a set of observed and unobserved variables. The objective in using SEM is to determine whether the ‘a priori’ model is valid, rather than to ‘find’ a suitable model (Gefen et al., 2000). IBM SPSS AMOS 23 was used for modelling.

Summated Scales

It is possible to model all the measured variables, in which case there is no measurement error present in the model. However, it is possible to replace the original set of variables with an entirely new, smaller set of variables created from summated scales. A summated scale can be formed by combining several individual variables into a single composite measure. In simple terms, all of the variables loading highly on a factor are combined, and the total—or more commonly the average score of the variables—is used as a replacement variable. This provides a means of overcoming to some extent the measurement error inherent in all measured variables (Hair et al., 2014). It also gives the ability to represent the multiple aspects of a concept in a single measure allowing for interpretation of the results and maintain parsimony in the number of variables in our multivariate models. Therefore, summated scales were created out of the factors obtained from Exploratory
Factor Analysis (EFA). Summated scales were created by combining several individual variables as obtained under each factor from EFA into a single composite measure.

There are various considerations while constructing summated scales. First is the Dimensionality i.e. all the variables under one scale are unidimensional, meaning that they are strongly associated with each other and represent a single concept. Next consideration is the reliability i.e. the degree to which the observed variable measures the “true” value and is “error free”. For determining reliability, the most commonly used type of diagnostic measure is the reliability coefficient, which assesses the consistency of the entire scale, with Cronbach’s alpha being the most widely used measure. The generally agreed upon lower limit for Cronbach’s alpha is .70. The final consideration is determining the validity of measurements. There are two types of validity widely considered,

1. Convergent validity assesses the degree to which two measures of the same concept are correlated. Construct Reliability (CR) is also an indicator of convergent validity. It is computed from the squared sum of factor loadings for each variable and the sum of the error variance terms for a variable.

2. Discriminant validity is the degree to which two conceptually similar concepts are distinct. As an acceptable EFA model cannot have cross-loadings, it provides evidence that every construct is unique and captures some phenomena other measures do not thereby, establishing discriminant validity.

Once the summated scales are developed they are used to in SEM model. To determine the measurement error in the summed scales Cronbach alpha values are used as they provide an indication on the measurement reliability (Molin, 2005). The measurement error of the summed scale is fixed by setting it equal to the observed variance of the summed scale times 1 minus the reliability, here represented by Cronbach’s alpha (Joreskog & Sorbom, 2001).

**Model Fit**

In structural equation modelling, evaluation of model fit is not as straightforward as it is in statistical approaches based on variables measured without error. Because there is no single statistical significance test that identifies a correct model given the sample data, it is necessary to take multiple criteria into consideration and to evaluate model fit on the basis of various measures simultaneously (Schermelleh-Engel et al., 2003). For each estimation procedure, a large number of
goodness-of-fit indices is provided to judge whether the model is consistent with the empirical data. For inferential statistical evaluation, only the $\chi^2$ test is available, whereas for descriptive evaluation, three main classes of criteria exist, i.e., measures of overall model fit, measures based on model comparisons, and measures of model parsimony (Schumacker & Lomax, 1996).

**$\chi^2$ test of Significance**

The $\chi^2$ test statistic is used for hypothesis testing to evaluate the appropriateness of a structural equation model. If the distributional assumptions are fulfilled, the $\chi^2$ test evaluates whether the population covariance matrix is equal to the model-implied covariance matrix. If the $p$-value associated with the $\chi^2$ value is larger than .05, the null hypothesis is accepted and the model is regarded as fit. There are several shortcomings associated with the $\chi^2$ test statistic. The $\chi^2$ test is based on the assumptions that the observed variables are multivariate normal and that the sample size is sufficiently large. Schermelleh-Engel et al. (2003), Jöreskog and Sörbom (1993) and Hair et al. (2014) suggest not too much emphasis should be placed on the significance of the $\chi^2$ statistic. Jöreskog and Sörbom (1993) propose to compare the magnitude of $\chi^2$ with the number of degrees of freedom(df). A value between 2 to 3 for the ratio $\chi^2 / df$ is indicative of a "good" or "acceptable" data-model fit. However, the problem of sample size dependency is not eliminated by this procedure (Bollen, 1989).

**Descriptive Goodness-of-Fit Measures**

Because of the drawbacks of the $\chi^2$ goodness-of-fit tests, numerous descriptive fit indices have been developed that are often assessed intuitively. As mentioned before, three main classes of criteria exist, i.e., measures of overall model fit, measures based on model comparisons, and measures of model parsimony. Measures of overall model fit indicate to which extent a structural equation model corresponds to the empirical data. The most commonly used measures are Root Mean Square Error of Approximation (RMSEA) and Standardized Root Mean Square Residual (SMR). The basic idea of comparison indices is that the fit of a model of interest is compared to the fit of some baseline model. Often used measures based on model comparisons are the Normed Fit Index (NFI), the Comparative Fit Index (CFI), and the Goodness-of-Fit Index (GFI). Parsimony is considered to be important in assessing model fit (Hu & Bentler, 1995) and serves as a criterion for choosing between alternative models. Since we are not comparing alternative models, these measures are not used to check model fit.
1. **Root Mean Square Error of Approximation (RMSEA)** – RMSEA assesses whether the model fits approximately well in the population (Kaplan, 2000). The null hypothesis of exact fit is replaced by the null hypothesis of "close fit" (Browne & Cudeck, 1993). According to Browne and Cudeck (1993), RMSEA values ≤ .05 can be considered as a good fit, values between .05 and .08 as an adequate fit, and values between .08 and .10 as a mediocre fit, whereas values > .10 are not acceptable.

2. **Standardized Root Mean Square Residual (SRMR)** – SRMR is also an overall fit measure which expresses the remaining discrepancies between the covariance matrices once the parameters of the model are estimated. SRMR values ≤ .05 can be considered as a good fit, values between .05 and .10 as an acceptable fit.

3. **Normed Fit Index (NFI)** – NFI is a ratio of the difference in the value for the fitted model and the null model divided by the value for the null model (Bentler and Bonnet, 1980). It ranges between zero to one. Although the theoretical boundary of NFI is one, NFI may not reach this upper limit even if the specified model is correct. The usual rule of thumb for this index is that .95 is indicative of good fit relative to the baseline model (Kaplan, 2000).

4. **Comparative Fit Index (CFI)** - The CFI is an incremental fit index that is an improved version of the NFI (Bentler, 1990). The CFI is Normed so that values range between zero to one, with higher values indicating better fit. Because the CFI has many desirable properties, including its relative, but not complete, insensitivity to model complexity, it is among the widely used indices. CFI values above 0.90 are usually associated with a model that fits well.

5. **Goodness-of-Fit Index (GFI)** - The Goodness-of-Fit-Index (GFI; Jöreskog & Sörbom, 1989) measures the relative amount of the variances and covariances in the empirical covariance matrix $S$ that is predicted by the model-implied covariance matrix. The GFI typically ranges between zero and one with higher values indicating better fit, but in some cases a negative GFI may occur. The usual rule of thumb for this index is that .95 is indicative of good fit relative to the baseline model, while values greater than .90 are usually interpreted as indicating an acceptable fit (Marsh & Grayson, 1995).
4.3.3. One Way ANOVA

ANOVA is a statistical technique for examining the differences among means for two or more populations. ANOVA is just a special case of regression (Field, 2009). It is important to realize that the one-way ANOVA is an omnibus test statistic and does not tell which specific groups were statistically significantly different from each other; it only tells you that at least two groups were different. In case of ANOVA, dependent variable should be measured at the interval or ratio level while the independent variable should consist of two or more categorical, independent groups.

The null hypothesis of one way ANOVA is that all means are equal. In examining the differences among means, one way analysis of variance involves the decomposition of the total variation observed in the dependent variable. This variation is measured by the sums of squares corrected for the mean (SS). Analysis of variance is so named because it examines the variability or variation in the sample (dependent variable) and, based on the variability, determines whether there is reason to believe that the population means differ. In this research, ANOVA is used to determine if demographic characteristics of the respondents (age, gender, education, and housing condition) influence their attitude, norms (personal and subjective), perceived behavioural control and intention to buy.

Post-Hoc Tests

As mentioned before one way ANOVA does not tell which specific groups were statistically significantly different from each other. For that, post-hoc tests can be used for exploring the data to see if any between-group differences between means that exist. Post hoc tests consist of pairwise comparisons that are designed to compare all different combinations of the treatment groups. So, it is rather like taking every pair of groups and then performing a t-test on each pair of groups. There are multiple post-hoc tests available, the choice of which depends on the inter-group sample sizes and group variances. Since the group sample sizes are very different in this case, Games-Howell procedure is used because this generally seems to offer the best performance (Field, 2009).

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5 Omnibus tests are a kind of statistical tests which test whether the explained variance in a set of data is significantly greater than the unexplained variance, overall
5. Results

The data used in the analysis of this research is a subset of the data collected from survey administered by the researcher. The survey discussed and developed in Section 4.1 was administered in the June-July 2017. The response rate was less than 10%. The original sample consisted of 173 respondents. Out of these, 23 respondents (13%) had smart HEMS or its components installed at their house. As the main dependent variable of the study is intention to buy, these respondents were not considered.

5.1. Descriptive Statistics

Table 1 provides a summary of demographic characteristics of the respondents. Out of the remaining 150 respondents, 100 were male while 50 were female. The data set was skewed young with more than 70% respondent with an age less than 35 years. Most of these respondents have either a bachelor’s degree or a master’s degree. The effect of convenience sampling is seen here. As the recruitment was from the network of the researcher, the responding sample was also young and with a bachelor/master degree. In terms of housing conditions, the majority of respondents rent their house/apartment as compared to owning a house/apartment. As seen from Table 2, the higher number of respondents with rented house/apartment is due to young age of respondents.

<table>
<thead>
<tr>
<th>Table 1 Summary of Demographic Characteristics</th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>GENDER</strong></td>
<td></td>
</tr>
<tr>
<td>Male</td>
<td>100</td>
</tr>
<tr>
<td>Female</td>
<td>50</td>
</tr>
<tr>
<td><strong>AGE</strong></td>
<td></td>
</tr>
<tr>
<td>18-24 years</td>
<td>37</td>
</tr>
<tr>
<td>25-34 years</td>
<td>72</td>
</tr>
<tr>
<td>35-44 years</td>
<td>20</td>
</tr>
<tr>
<td>45-54 years</td>
<td>21</td>
</tr>
<tr>
<td><strong>EDUCATION</strong></td>
<td></td>
</tr>
<tr>
<td>Some college credits</td>
<td>2</td>
</tr>
<tr>
<td>High school graduate</td>
<td>12</td>
</tr>
<tr>
<td>Trade/technical/vocational training</td>
<td>1</td>
</tr>
<tr>
<td>Professional degree</td>
<td>4</td>
</tr>
</tbody>
</table>
Bachelor's degree | 63
Master's degree | 66
Doctorate | 2

**HOUSING**

Rent | 86
Own | 58
Other | 6

Table 2 Cross-Table: Age vs. Housing Condition

<table>
<thead>
<tr>
<th>AGE</th>
<th>Other</th>
<th>Own</th>
<th>Rent</th>
<th>Total</th>
</tr>
</thead>
<tbody>
<tr>
<td>18-24 years</td>
<td>2</td>
<td>7</td>
<td>28</td>
<td>37</td>
</tr>
<tr>
<td>25-34 years</td>
<td>4</td>
<td>20</td>
<td>48</td>
<td>72</td>
</tr>
<tr>
<td>35-44 years</td>
<td>0</td>
<td>18</td>
<td>2</td>
<td>20</td>
</tr>
<tr>
<td>45-54 years</td>
<td>0</td>
<td>13</td>
<td>8</td>
<td>21</td>
</tr>
<tr>
<td><strong>Total</strong></td>
<td>6</td>
<td>58</td>
<td>86</td>
<td>150</td>
</tr>
</tbody>
</table>

Figure 8 shows the means and standard deviation of the variables.

Table 3 List of constructs and items used for measuring them

<table>
<thead>
<tr>
<th>Construct</th>
<th>Items</th>
</tr>
</thead>
<tbody>
<tr>
<td>Compatibility</td>
<td>COM1, COM2</td>
</tr>
<tr>
<td>Autonomy</td>
<td>AUT1, AUT2</td>
</tr>
<tr>
<td>Feedback</td>
<td>FED1, FED2, FED3</td>
</tr>
<tr>
<td>Privacy</td>
<td>PRI, PRI2, PRI3</td>
</tr>
<tr>
<td>Attitude</td>
<td>ATT1, ATT2</td>
</tr>
<tr>
<td>Subjective Norm</td>
<td>SUN1, SUN2</td>
</tr>
<tr>
<td>Perceived Behavioural Control</td>
<td>PBC1, PBC2, PBC3</td>
</tr>
<tr>
<td>Responsibility</td>
<td>RES1, RES2, RES3</td>
</tr>
<tr>
<td>Sustainability</td>
<td>SUS1, SUS2</td>
</tr>
<tr>
<td>Personal Norms</td>
<td>PEN1, PEN2</td>
</tr>
<tr>
<td>Intention to buy</td>
<td>IEB1, IEB2, IEB3</td>
</tr>
<tr>
<td>Trust &amp; Fairness</td>
<td>TRU1</td>
</tr>
<tr>
<td>Fairness</td>
<td>DIF1</td>
</tr>
<tr>
<td>Knowledge</td>
<td>FAM1</td>
</tr>
</tbody>
</table>
### Figure 8 Descriptive Statistics

<table>
<thead>
<tr>
<th>Variable</th>
<th>Mean</th>
<th>Std. Deviation</th>
</tr>
</thead>
<tbody>
<tr>
<td>IEB3</td>
<td>3.28</td>
<td>1.165</td>
</tr>
<tr>
<td>IEB2</td>
<td>3.06</td>
<td>1.211</td>
</tr>
<tr>
<td>IEB1</td>
<td>3.28</td>
<td>1.118</td>
</tr>
<tr>
<td>PEN2</td>
<td>2.287</td>
<td>1.206</td>
</tr>
<tr>
<td>PEN1</td>
<td>2.93</td>
<td>1.127</td>
</tr>
<tr>
<td>RES3</td>
<td>4.07</td>
<td>0.921</td>
</tr>
<tr>
<td>RES2</td>
<td>4.233</td>
<td>0.891</td>
</tr>
<tr>
<td>RES1</td>
<td>3.647</td>
<td>1.705</td>
</tr>
<tr>
<td>PBC3</td>
<td>3.04</td>
<td>1.336</td>
</tr>
<tr>
<td>PBC2</td>
<td>2.867</td>
<td>1.278</td>
</tr>
<tr>
<td>PBC1</td>
<td>2.093</td>
<td>1.25</td>
</tr>
<tr>
<td>SUN2</td>
<td>2.74</td>
<td>1.126</td>
</tr>
<tr>
<td>SUN1</td>
<td>2.673</td>
<td>1.19</td>
</tr>
<tr>
<td>ATT2</td>
<td>3.672</td>
<td>0.923</td>
</tr>
<tr>
<td>ATT1</td>
<td>3.7</td>
<td>0.903</td>
</tr>
<tr>
<td>SUS2</td>
<td>3.907</td>
<td>0.985</td>
</tr>
<tr>
<td>SUS1</td>
<td>3.893</td>
<td>0.949</td>
</tr>
<tr>
<td>DIF1</td>
<td>3.473</td>
<td>0.917</td>
</tr>
<tr>
<td>TRU1</td>
<td>2.847</td>
<td>1.008</td>
</tr>
<tr>
<td>PRI3</td>
<td>2.753</td>
<td>1.321</td>
</tr>
<tr>
<td>PRI2</td>
<td>3.047</td>
<td>1.318</td>
</tr>
<tr>
<td>PRI1</td>
<td>3.02</td>
<td>1.378</td>
</tr>
<tr>
<td>FED3</td>
<td>4.213</td>
<td>0.856</td>
</tr>
<tr>
<td>FED2</td>
<td>4.313</td>
<td>0.891</td>
</tr>
<tr>
<td>FED1</td>
<td>4.087</td>
<td>1.068</td>
</tr>
<tr>
<td>AUT2</td>
<td>3.093</td>
<td>1.172</td>
</tr>
<tr>
<td>AUT1</td>
<td>2.833</td>
<td>1.308</td>
</tr>
<tr>
<td>COM2</td>
<td>3.993</td>
<td>1.033</td>
</tr>
<tr>
<td>COM1</td>
<td>3.487</td>
<td>0.988</td>
</tr>
<tr>
<td>FAM1</td>
<td>2.347</td>
<td>1.248</td>
</tr>
</tbody>
</table>
5.2. Exploratory Factor Analysis

As discussed earlier in Section 4.3.1, for conducting an exploratory factor analysis, the number of factors was fixed to 12, the extraction method chosen was Principle Component Analysis (PCA) and the rotation method was set to PROMAX. For the results, based on the suggestions of Hair et al. (2014), factor coefficients with absolute value below 0.4 were suppressed even though they are computed by the software.

Bartlett’s Test & Measures of Sampling Adequacy (MSA)

Bartlett’s Test of Sphericity checks whether data reduction is possible or not. As seen from Figure 9, the significance of the Bartlett’s Test is .000 (p<0.05), therefore the null hypothesis of the test can be rejected and it can be concluded that data reduction is possible on the data.

According to Hair et al. (2014), the MSA for both the overall test and each individual variable must exceed 0.50. The Kaiser-Meyer-Olkin Measure of Sampling Adequacy provides the MSA for overall test and from Figure 9 we can see that it is greater than 0.5 (.766). Table 4 provides with MSA values for all the individual variables considered in the Exploratory Factor Analysis. It can be seen that all the MSA values are above 0.5. Table 4 also provides with the communalities of the variables. According to Hair et al. (2014), all variables with communalities greater than 0.50 should be retained in the analysis. All the variables will be retained as value communalities for all the variables is higher than 0.50.

The Bartlett test and the MSA together allow the researcher to assess the overall significance of the correlation matrix. Since the conditions of both the tests are met, we can conclude that the resulting factor structure has some objective basis. Thus, EFA was deemed to be suitable.
### Table 4 Variable MSA values

<table>
<thead>
<tr>
<th>Variable</th>
<th>MSA</th>
<th>Communalities</th>
</tr>
</thead>
<tbody>
<tr>
<td>COM1</td>
<td>0.563</td>
<td>0.857</td>
</tr>
<tr>
<td>COM2</td>
<td>0.598</td>
<td>0.846</td>
</tr>
<tr>
<td>AUT1</td>
<td>0.569</td>
<td>0.899</td>
</tr>
<tr>
<td>AUT2</td>
<td>0.557</td>
<td>0.910</td>
</tr>
<tr>
<td>FED1</td>
<td>0.793</td>
<td>0.710</td>
</tr>
<tr>
<td>FED2</td>
<td>0.759</td>
<td>0.771</td>
</tr>
<tr>
<td>FED3</td>
<td>0.822</td>
<td>0.799</td>
</tr>
<tr>
<td>PRI1</td>
<td>0.716</td>
<td>0.913</td>
</tr>
<tr>
<td>PRI2</td>
<td>0.677</td>
<td>0.925</td>
</tr>
<tr>
<td>PRI3</td>
<td>0.79</td>
<td>0.810</td>
</tr>
<tr>
<td>TRU1</td>
<td>0.833</td>
<td>0.744</td>
</tr>
<tr>
<td>ATT1</td>
<td>0.796</td>
<td>0.882</td>
</tr>
<tr>
<td>ATT2</td>
<td>0.857</td>
<td>0.819</td>
</tr>
<tr>
<td>SUN1</td>
<td>0.773</td>
<td>0.880</td>
</tr>
<tr>
<td>SUN2</td>
<td>0.765</td>
<td>0.897</td>
</tr>
</tbody>
</table>

### Table 5 Eigen Values and explained variance

<table>
<thead>
<tr>
<th>Factor</th>
<th>Total</th>
<th>% of Variance</th>
<th>Cumulative %</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>7,312</td>
<td>25,213</td>
<td>25,213</td>
</tr>
<tr>
<td>2</td>
<td>3,066</td>
<td>10,572</td>
<td>35,785</td>
</tr>
<tr>
<td>3</td>
<td>2,766</td>
<td>9,539</td>
<td>45,324</td>
</tr>
<tr>
<td>4</td>
<td>2,136</td>
<td>7,364</td>
<td>52,689</td>
</tr>
<tr>
<td>5</td>
<td>1,829</td>
<td>6,306</td>
<td>58,994</td>
</tr>
<tr>
<td>6</td>
<td>1,639</td>
<td>5,652</td>
<td>64,646</td>
</tr>
<tr>
<td>7</td>
<td>1,203</td>
<td>4,149</td>
<td>68,795</td>
</tr>
<tr>
<td>8</td>
<td>1,152</td>
<td>3,974</td>
<td>72,769</td>
</tr>
<tr>
<td>9</td>
<td>0.941</td>
<td>3,245</td>
<td>76,013</td>
</tr>
</tbody>
</table>

### Number of Factors

The number of factors was fixed to 12 as discussed in an earlier section. Table 5 provides with the Eigen values for these 12 factors along with the explained variance. The 12 factors as extracted explain 83.5% of the variance, which is higher than the lower limit of 60% as suggested by Hair et al. (2014). It should be noted that only 8 of these factors satisfy the Kaiser criterion (Eigen value > 1). However, it has been noted by the authors like Osborne & Banjanovic (2009), that this criterion is slightly unreliable. Using just 8 factors (factors with eigen values > 1), results in a solution where the rotated factors do not make sense theoretically i.e. the variables that are loading on the same factor do not make sense together. Therefore, it was decided to retain 12 factors.
Factor Loadings

Table 6 shows the factor-loading matrix which contains the rotated significant factor loading of each variable on each factor. In this research, factor loadings of .40 and higher are considered significant. Using this threshold for the factor loadings, we can see that the loadings for every variable is aligned to the objective of having a high loading on only a single factor. We also find that there is no cross-loading of variables on factors. Another step in assessing the factors is verifying the communalities of the variables. This has been already verified in earlier step. As there are no variables without any significant loading, with low communality or with cross loading, no re-specification of the model is needed. With an acceptable factor solution reached, the 12 factors are labelled as shown in the top row of Table 6.

From the Table 6, we can see that the constructs that are theoretically distinct are also found to be empirically distinct. However, there is one exception to this. It is found that the measures for Trust and Fairness load on the same factor. This means that they are correlated to each other and not independent as assumed earlier. Few authors have predicted/modelled that fairness and trust influence one another (Huijts et al., 2012).
Table 6 Factor Loadings

<table>
<thead>
<tr>
<th>Privacy Intention</th>
<th>Perceived Behavioural Control</th>
<th>Autonomy</th>
<th>Sustainability</th>
<th>Compatibility</th>
<th>Trust &amp; Fairness</th>
</tr>
</thead>
<tbody>
<tr>
<td>Component 1</td>
<td>Component 2</td>
<td>Component 3</td>
<td>Component 4</td>
<td>Component 5</td>
<td>Component 6</td>
</tr>
<tr>
<td>PRI1</td>
<td>PRI2</td>
<td>PRI3</td>
<td>IEB1</td>
<td>IEB2</td>
<td>IEB3</td>
</tr>
<tr>
<td>0.956</td>
<td>0.952</td>
<td>0.907</td>
<td>0.841</td>
<td>0.813</td>
<td>0.775</td>
</tr>
<tr>
<td>PRI1</td>
<td>PRI2</td>
<td>PRI3</td>
<td>IEB1</td>
<td>IEB2</td>
<td>IEB3</td>
</tr>
<tr>
<td>0.956</td>
<td>0.952</td>
<td>0.907</td>
<td>0.841</td>
<td>0.813</td>
<td>0.775</td>
</tr>
<tr>
<td>PBC1</td>
<td>PBC2</td>
<td>PBC3</td>
<td>RES1</td>
<td>RES2</td>
<td>RES3</td>
</tr>
<tr>
<td>0.913</td>
<td>0.775</td>
<td>0.813</td>
<td>0.737</td>
<td>0.690</td>
<td>0.912</td>
</tr>
<tr>
<td>PBC1</td>
<td>PBC2</td>
<td>PBC3</td>
<td>RES1</td>
<td>RES2</td>
<td>RES3</td>
</tr>
<tr>
<td>0.913</td>
<td>0.775</td>
<td>0.813</td>
<td>0.737</td>
<td>0.690</td>
<td>0.912</td>
</tr>
<tr>
<td>FED1</td>
<td>FED2</td>
<td>FED3</td>
<td>AUT1</td>
<td>AUT2</td>
<td>AUT3</td>
</tr>
<tr>
<td>0.853</td>
<td>0.737</td>
<td>0.690</td>
<td>0.912</td>
<td>0.888</td>
<td>0.798</td>
</tr>
<tr>
<td>FED1</td>
<td>FED2</td>
<td>FED3</td>
<td>AUT1</td>
<td>AUT2</td>
<td>AUT3</td>
</tr>
<tr>
<td>0.853</td>
<td>0.737</td>
<td>0.690</td>
<td>0.912</td>
<td>0.888</td>
<td>0.798</td>
</tr>
<tr>
<td>PEN1</td>
<td>PEN2</td>
<td>PEN3</td>
<td>SUS1</td>
<td>SUS2</td>
<td>SUS3</td>
</tr>
<tr>
<td>0.798</td>
<td>0.761</td>
<td>0.860</td>
<td>0.936</td>
<td>0.899</td>
<td>0.859</td>
</tr>
<tr>
<td>PEN1</td>
<td>PEN2</td>
<td>PEN3</td>
<td>SUS1</td>
<td>SUS2</td>
<td>SUS3</td>
</tr>
<tr>
<td>0.798</td>
<td>0.761</td>
<td>0.860</td>
<td>0.936</td>
<td>0.899</td>
<td>0.859</td>
</tr>
<tr>
<td>PEN1</td>
<td>PEN2</td>
<td>PEN3</td>
<td>SUS1</td>
<td>SUS2</td>
<td>SUS3</td>
</tr>
<tr>
<td>0.798</td>
<td>0.761</td>
<td>0.860</td>
<td>0.936</td>
<td>0.899</td>
<td>0.859</td>
</tr>
<tr>
<td>PEN1</td>
<td>PEN2</td>
<td>PEN3</td>
<td>SUS1</td>
<td>SUS2</td>
<td>SUS3</td>
</tr>
<tr>
<td>0.798</td>
<td>0.761</td>
<td>0.860</td>
<td>0.936</td>
<td>0.899</td>
<td>0.859</td>
</tr>
</tbody>
</table>

Component 1 converged in 7 iterations.
Component 2 converged in 12 iterations.
Component 3 converged in 7 iterations.
Component 4 converged in 7 iterations.
Component 5 converged in 7 iterations.
Component 6 converged in 7 iterations.
5.3. Structural Equation Modelling

5.3.1. Summated Scales

The factors as obtained from Exploratory Factor Analysis can be used to identify appropriate variables for further statistical analysis (like SEM; Hair et al., 2014). As discussed in earlier section, there are various considerations while creating summated scales. The first consideration of unidimensionality has already been verified in the EFA as there are no significant cross loadings. For the reliability analysis, the diagnostic measure used is the reliability coefficient. From Table 7 we can see that all the alpha values are higher than the lower limit of 0.70 making the data set reliable. The final consideration is establishing the convergent and discriminant validity of the scale. Discriminant validity is already established through the acceptable solution of EFA as all factors are different without any cross loading of variables. To establish convergent validity, construct reliability is used. From Table 7 we can see that all the construct reliability values are above 0.70 threshold providing adequate evidence of convergent validity.

<table>
<thead>
<tr>
<th>Construct</th>
<th>Items</th>
<th>Cronbach's Alpha</th>
<th>Construct Reliability</th>
</tr>
</thead>
<tbody>
<tr>
<td>Compatibility</td>
<td>COM1, COM2</td>
<td>0.781</td>
<td>0.893</td>
</tr>
<tr>
<td>Autonomy</td>
<td>AUT1, AUT2</td>
<td>0.890</td>
<td>0.940</td>
</tr>
<tr>
<td>Feedback</td>
<td>FED1, FED2, FED3</td>
<td>0.703</td>
<td>0.804</td>
</tr>
<tr>
<td>Privacy</td>
<td>PRI, PRI2, PRI3</td>
<td>0.929</td>
<td>0.946</td>
</tr>
<tr>
<td>Attitude</td>
<td>ATT1, ATT2</td>
<td>0.863</td>
<td>0.730</td>
</tr>
<tr>
<td>Subjective Norm</td>
<td>SUN1, SUN2</td>
<td>0.902</td>
<td>0.891</td>
</tr>
<tr>
<td>Perceived Behavioural Control</td>
<td>PBC1, PBC2, PBC3</td>
<td>0.862</td>
<td>0.916</td>
</tr>
<tr>
<td>Responsibility</td>
<td>RES1, RES2, RES3</td>
<td>0.811</td>
<td>0.865</td>
</tr>
<tr>
<td>Sustainability</td>
<td>SUS1, SUS2</td>
<td>0.857</td>
<td>0.794</td>
</tr>
<tr>
<td>Personal Norms</td>
<td>PEN1, PEN2</td>
<td>0.832</td>
<td>0.872</td>
</tr>
<tr>
<td>Intention to buy</td>
<td>IEB1, IEB2, IEB3</td>
<td>0.903</td>
<td>0.880</td>
</tr>
<tr>
<td>Trust &amp; Fairness</td>
<td>DIF1, TRU1</td>
<td>0.706</td>
<td>0.792</td>
</tr>
</tbody>
</table>

Thus, a summated scale was created for each of the above constructs using the items under them. The summated scales were calculated by taking the average of the items in the scale. Figure 10 provides the descriptive statistics of the summated scales.
5.3.2. Estimation and Model Fit

IBM SPSS AMOS was used for modelling the SEM model. The measurement error for each latent variable was fixed to a value equal to $\sigma \times (1 - \alpha)$ where, $\sigma$ is the observed variance and $\alpha$ is the reliability. The initial model was estimated based on the theoretical model i.e. the causal relations between variables was based on the theoretical model. Furthermore, no reversal causality or feedback loops are assumed, resulting in a recursive model. All the 12 factors as obtained from the EFA were included as latent variables, represented by ovals in the model. Knowledge was also included as latent variable. Cronbach alpha could not be calculated for Knowledge as it has a single measure, so it was assumed to be measure with average reliability ($\alpha = 0.84$). As it is a standard procedure with SEM modelling, correlation was modelled between all the exogenous variables and also between the error variance terms of endogenous variables (Attitude, Perceived Behavioural Control, Personal Norms, and Subjective Norms).

The model was then estimated using the Maximum Likelihood method. The estimated model had a poor fit ($\chi^2 = 101.736; df = 37; p = .000; CFI = 0.850$. To improve the model fitness, a few modification indices were suggested by the software. However, none of the suggested modification
indices have any theoretical backing and hence were not considered. As a final step, all the non-significant paths were removed. The resulting model does not meet the criteria for $\chi^2(=34.1)$ test of significance of $p(0.019)<0.05$. However, as discussed before in the model fit section, model fit cannot be based on $\chi^2$ test. Table 8 provides the various measures used for determining model fitness along with the suggested values. From the table, we can see that the model has an acceptable to good fit according to various measures.

Table 8 Model Fitness Measures

<table>
<thead>
<tr>
<th>Measure</th>
<th>Rules Of Thumb For Fitness</th>
<th>Value</th>
<th>Fitness</th>
</tr>
</thead>
</table>
| $\chi^2$/df | Good: $0 \leq \chi^2$/df $\leq 2$   
Acceptable: $2 < \chi^2$/df $\leq 3$ | 1.892 | Good Fit  |
| RMSEA     | Good: $0 \leq \text{RMSEA} \leq 0.05$   
Acceptable: $0.05 < \text{RMSEA} \leq 0.08$ | 0.077 | Acceptable Fit |
| SRMR      | Good: $0 \leq \text{SRMR} \leq 0.05$   
Acceptable: $0.05 < \text{SRMR} \leq 0.10$ | 0.066 | Acceptable Fit |
| NFI       | Good: $0.95 \leq \text{NFI} \leq 1.00$   
Acceptable: $0.90 \leq \text{NFI} < 0.95$ | 0.907 | Acceptable Fit |
| CFI       | Good: $0.95 \leq \text{CFI} \leq 1.00$   
Acceptable: $0.90 \leq \text{CFI} < 0.95$ | 0.951 | Good Fit  |
| GFI       | Good: $0.95 \leq \text{GFI} \leq 1.00$   
Acceptable: $0.90 \leq \text{GFI} < 0.95$ | 0.955 | Good Fit  |

Figure 11 shows the final model with just the significant paths. The path coefficients in the diagram can be interpreted as standardized regression coefficients. For ease of presentation, the indicators of the latent variables and all error terms are left out of the figure. Table 9 presents the standardized total effects of the independent variables on the dependent (latent) variables and the percentage explained variance. Total effect is the summation of direct and indirect effect. An indirect effect is calculated by taking the product of the estimated coefficients of the paths that connect two variables.
Figure 11: Model explaining intention to buy Smart HEMS

Perceived Behavioral Control

- Personal Norm
  - $p \leq 0.05$
  - $p \leq 0.01$

- Subjective Norm
  - $p \leq 0.05$
  - $p \leq 0.01$

- Perceived
  - $p \leq 0.05$
  - $p \leq 0.01$

- Attitude
  - $p \leq 0.05$
  - $p \leq 0.01$

- Knowledge
  - $p \leq 0.05$
  - $p \leq 0.01$

- Trust & Fairness
  - $p \leq 0.05$
  - $p \leq 0.01$

- Sustainability
  - $p \leq 0.05$
  - $p \leq 0.01$

- Feedback
  - $p \leq 0.05$
  - $p \leq 0.01$

$0.05 > d \quad **$

$0.01 > d \quad ***$
<table>
<thead>
<tr>
<th>Independent Variables</th>
<th>Dependent</th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Attitude</td>
<td>Intention to Buy/ Use</td>
</tr>
<tr>
<td>Feedback</td>
<td>0,207</td>
<td>0,094</td>
</tr>
<tr>
<td>Sustainability</td>
<td>0,430</td>
<td>0,194</td>
</tr>
<tr>
<td>Trust &amp; Fairness</td>
<td>0,384</td>
<td>0,173</td>
</tr>
<tr>
<td>Attitude</td>
<td></td>
<td>0,452</td>
</tr>
<tr>
<td>Knowledge</td>
<td></td>
<td>0,174</td>
</tr>
<tr>
<td>Subjective Norms</td>
<td></td>
<td>0,158</td>
</tr>
<tr>
<td>Personal Norms</td>
<td></td>
<td>0,349</td>
</tr>
<tr>
<td>Perceived Behavioural Control</td>
<td></td>
<td>0,181</td>
</tr>
<tr>
<td>% Variance Explained</td>
<td>64.8</td>
<td>63.0</td>
</tr>
</tbody>
</table>

It was discussed before that the inclusion of personal norms in the model is an empirical one. To check the effect of personal norms, the model from Figure 11 was modelled without personal norms and the analysis was run again. As expected the removal of personal norms from the model decrease the degrees freedom (from 18 to 13), and thus the model fitness improved ($\chi^2 = 19.53; \text{df } = 13; \chi^2/\text{df } = 1.503; \text{SRMR } = 0.059; \text{RMSEA } = 0.058; \text{CFI } = 0.975; \text{NFI } = 0.932; \text{GFI } = 0.968$). All the model fitness measures are slightly better in this iteration as compared to earlier one which included personal norms. However, the exclusion of personal norms decreased the explained variance of the intention to buy by 10.5% (from 63% to 57%). Thus, it was decided to retain personal norms in the model.

### 5.4. One Way ANOVA

One way ANOVA is used to determine if demographic characteristics of the respondents (age, gender, education, and housing condition) influence their attitude, norms (personal and subjective), perceived behavioural control and intention to buy. Table 8 below provides the results of the analysis. The significant results ($p<0.05$) for which null hypothesis is rejected (i.e. the two populations are different) are highlighted. There was a significant effect of Age on Perceived Behavioural Control (PBC), $F(3, 146) = 4.06, p < .05$. A significant effect of Age on Personal Norm (PEN), $F(3, 146) = 7.482, p < .05$ and on Intention to Buy (IEB), $F(3, 146) = 4.607, p < .05$ was also found. There was a significant effect of Housing condition on Perceived Behavioural Control (PBC), $F(2, 147) = 3.291, p < .05$. 
<table>
<thead>
<tr>
<th>Independent Variable</th>
<th>Dependent Variable</th>
<th>ANOVA</th>
<th>Welch Test of Equality of Means</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td>Mean</td>
<td>DF</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Square</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Age</td>
<td>Attitude</td>
<td>2.397</td>
<td>3</td>
</tr>
<tr>
<td></td>
<td>Perceived Behavioural Control</td>
<td>2.208</td>
<td>3</td>
</tr>
<tr>
<td></td>
<td>Subjective Norm</td>
<td>0.934</td>
<td>3</td>
</tr>
<tr>
<td></td>
<td>Personal Norm</td>
<td>0.017</td>
<td>3</td>
</tr>
<tr>
<td></td>
<td>Intention to Buy</td>
<td>0.738</td>
<td>3</td>
</tr>
<tr>
<td>Gender</td>
<td>Attitude</td>
<td>2.470</td>
<td>1</td>
</tr>
<tr>
<td></td>
<td>Perceived Behavioural Control</td>
<td>2.470</td>
<td>1</td>
</tr>
<tr>
<td></td>
<td>Subjective Norm</td>
<td>0.003</td>
<td>1</td>
</tr>
<tr>
<td></td>
<td>Personal Norm</td>
<td>0.030</td>
<td>1</td>
</tr>
<tr>
<td></td>
<td>Intention to Buy</td>
<td>0.278</td>
<td>2</td>
</tr>
<tr>
<td>Housing Condition</td>
<td>Attitude</td>
<td>1.297</td>
<td>2</td>
</tr>
<tr>
<td></td>
<td>Perceived Behavioural Control</td>
<td>1.297</td>
<td>2</td>
</tr>
<tr>
<td></td>
<td>Subjective Norm</td>
<td>0.627</td>
<td>2</td>
</tr>
<tr>
<td></td>
<td>Personal Norm</td>
<td>0.765</td>
<td>2</td>
</tr>
<tr>
<td></td>
<td>Intention to Buy</td>
<td>0.278</td>
<td>2</td>
</tr>
<tr>
<td>Education</td>
<td>Attitude</td>
<td>1.162</td>
<td>5</td>
</tr>
<tr>
<td></td>
<td>Perceived Behavioural Control</td>
<td>1.162</td>
<td>5</td>
</tr>
<tr>
<td></td>
<td>Subjective Norm</td>
<td>0.317</td>
<td>5</td>
</tr>
<tr>
<td></td>
<td>Personal Norm</td>
<td>0.670</td>
<td>5</td>
</tr>
<tr>
<td></td>
<td>Intention to Buy</td>
<td>0.765</td>
<td>5</td>
</tr>
</tbody>
</table>
For these significant relationships, a post-hoc (Games-Howell) test was performed. The means for the groups of age and housing condition for the respective dependent variables were plotted and are shown in Figure 12 and Figure 13. From the results of the post-hoc test, as shown in table 8, we can conclude that respondents between age 25-34,

1. Feel higher perceived behavioural control than the ones between 35-44
2. Higher intention to buy and stronger personal norms than respondents with age 18-24
3. Stronger personal norms than respondents with age 45-54.

There is no significant difference between the housing condition groups and Perceived Behavioural Control as seen both from Table 9 and Figure 13.

Table 11 Post-Hoc Test ANOVA results

<table>
<thead>
<tr>
<th>Dependent</th>
<th>Age</th>
<th>Mean</th>
<th>Significant difference</th>
</tr>
</thead>
<tbody>
<tr>
<td>IEB</td>
<td>18-24 years</td>
<td>2.712</td>
<td>Yes</td>
</tr>
<tr>
<td></td>
<td>25-34 years</td>
<td>3.472</td>
<td></td>
</tr>
<tr>
<td></td>
<td>35-44 years</td>
<td>3.300</td>
<td></td>
</tr>
<tr>
<td></td>
<td>45-54 years</td>
<td>3.079</td>
<td></td>
</tr>
<tr>
<td>PBC</td>
<td>18-24 years</td>
<td>3.198</td>
<td>Yes</td>
</tr>
<tr>
<td></td>
<td>25-34 years</td>
<td>3.139</td>
<td></td>
</tr>
<tr>
<td></td>
<td>35-44 years</td>
<td>2.417</td>
<td></td>
</tr>
<tr>
<td></td>
<td>45-54 years</td>
<td>2.492</td>
<td></td>
</tr>
<tr>
<td>PEN</td>
<td>18-24 years</td>
<td>1.784</td>
<td>Yes</td>
</tr>
<tr>
<td></td>
<td>25-34 years</td>
<td>2.639</td>
<td></td>
</tr>
<tr>
<td></td>
<td>45-54 years</td>
<td>1.833</td>
<td></td>
</tr>
<tr>
<td></td>
<td>35-44 years</td>
<td>2.450</td>
<td></td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Dependent</th>
<th>Housing Condition</th>
<th>Mean</th>
</tr>
</thead>
<tbody>
<tr>
<td>PBC</td>
<td>Other</td>
<td>2.889</td>
</tr>
<tr>
<td></td>
<td>Rent</td>
<td>3.047</td>
</tr>
<tr>
<td></td>
<td>Own</td>
<td>2.753</td>
</tr>
</tbody>
</table>

Figure 12 Means of Age Groups for Intention, PBC and Personal Norms
Figure 13 Means of Housing Groups for PBC
6. Discussion

Figure 11 provides the path model of the estimated model as obtained from the SEM analysis. The path coefficients that are shown in the figure can be interpreted as standardized regression coefficients. Table 9 provides the total effects of the variables and the percentage explained variance of all dependent variables. Total effects are summation of direct and indirect effects where the indirect effects are calculated by taking the product of the estimated coefficients of the paths that connect two variables. The estimated model explains 63% of the variance in Intention to buy. In the following section, we discuss the direct effects as they are relevant to the hypotheses of this research.

Intention to use is directly influenced by Knowledge (0.174): more knowledge of the system leads to more intention to buy HEMS technology. This is expected because when confronted with a behavioural decision people engage in cognitive process which is affected by their knowledge (Fabrigar et al., 2006). Existing knowledge thus, affects the cognitive processes related to a consumer’s decision and determines his ability to understand and use a technology (Bauer et al, 2005). However, it was also hypothesised that Knowledge affects intentions through attitude towards the technology. This relationship was found to be not significant. Fabrigar et al. (2006) suggest that along with the amount, content and relevance of knowledge may often impact attitude. According to them, even though amount and complexity of knowledge are likely to be positively correlated, they are conceptually and operationally distinguishable. Thus, there is a requirement to research on the role of complexity of knowledge as a determinant of attitude.

Intention to use is directly influenced by the Personal Norms of the individual (0.349): stronger feelings of moral (personal) obligation act as motivations to perform behaviour. This is as predicted by Schwartz in his Norm Activation Model (NAM). Acting on the basis of self-expectations can lead pride, self-esteem and other favourable personal evaluations. It was hypothesised that feelings of responsibility can lead to stronger personal norms, however this relationship was found to be not significant. The causal relationships between the constructs in NAM has been a contentious issue in itself with multiple interpretation by different authors. Two of these interpretations were presented in the section on discussion of NAM. In this research, the mediating model of responsibility and personal norms was assumed, modelled and found to be
insignificant. Whether responsibility moderates the effect on personal norms on intention requires further analysis.

Subjective Norms (0.158) as predicted by the theoretical model on the basis of Theory of Planned Behaviour directly influenced the intention to buy. The important point to note for subjective norms is the strong correlation between them and personal norms as seen in the Figure 11. Subjective norms are located within the broader construct of social norms (Ajzen, 1991). According to Schwartz (1977), an overlap between personal norms held by individuals and prevailing social norm is possible. However, social norms are perceived to be shared by members of a group, personal norms typically vary from one individual to another and hence are to be treated as separate constructs.

Intention to use is directly influenced by Perceived Behavioural Control (0.181): Higher the resources and opportunities available to a person higher would be the probability of performing a behaviour. However, it is important to note here that the importance of PBC on intentions is expected to vary across situations. This importance may also be affected by any intervening events as they might change the perceptions of control.

Finally, Intention to use is directly influenced by Attitude (0.452) as predicted by Theory of Planned Behaviour, thus positive attitude towards the technology leads to a stronger intention to buy the technology. Among all the dependent variables, Attitude has the strongest direct (and total) effect on the intention. Attitude has three preceding constructs in the form of Feedback, Sustainability and Trust & Fairness.

Among the preceding constructs of Attitude, Sustainability has the strongest effect on Attitude (0.430). Smart HEMS systems which are sustainable enables users to form strong belief that the use of these systems will lead to most positive outcome in the form of efficient and effective energy consumption. Feedback from the system is another construct which has effect on Attitude (0.207). Good feedback from the system on the energy consumption habits can help the users to improve them. This positive outcome of the behaviour is evaluated favourably by the respondents. Finally, Trust & Fairness have an effect on the Attitude (0.384). With smart HEMS being a relatively new technology, in which case trust in the system developer will have an effect on attitude as it will influence user’s perception towards the system. Thus, if the users trust the system developers they will have a positive attitude towards the technology. Similarly, if the users feel that the benefits and
drawbacks from using the HEMS system are fair then that would be evaluated favourably which will lead to a positive attitude towards the system.

Privacy, Autonomy and Compatibility were found to have a non-significant effect on the attitude towards the system. Most research in this domain list privacy as one of the important factor for acceptance. This means that respondents feel that the current smart HEMS system do not violate their privacy. In case of compatibility, discussions with some of the respondents revealed that having compatibility with legacy systems can increase complexity of the system, affect its performance and would increase the cost of system. According to them, the turnover rate of technology is quite high in current times and thus ensuring compatibility with older systems was not overtly important. Lack of autonomy occurs because the technology acts on behalf of the user. However, it seems that users don’t mind the increased automation of activities in their daily life. It seems they feel that the technology is advanced far enough to make appropriate decisions in choosing its mode of operation and also that of other systems.

In case of demographic characteristics, it is clear that Age has significant effect on perceived behavioural control (PBC), intention to buy and personal norms while Housing condition of the respondent affects just their PBC. In case of age we see that the group of respondents between 25-34 year old have higher means than those between 18-24 years and also 35+ years for PBC, intentions and personal norms. This may be because these group of people are more educated and informed than the younger audience and but have stronger intentions to buy than older populations as seen in the classic technology acceptance literature. The age group 18-24 is an exception as they have lower intentions to buy which is not expected but can be explained by the fact that these consumers may not have decision making capability, live in rented accommodations, lack appropriate financial resources and also don’t feel as strongly morally obligated as yet.

The effect of housing condition on the PBC is as expected because if the respondents live in a rented accommodation, they do not really have the decision power to install smart HEMS as it may rest with house/apartment owner. These people may also be financially constrained (as in the case of this research, the respondents who rent are also more likely to be young).
6.1. Summary of Hypotheses

Table 12 Summary of Hypotheses

<table>
<thead>
<tr>
<th>Hypothesis</th>
<th>Finding</th>
</tr>
</thead>
<tbody>
<tr>
<td>H1 – lack of privacy negatively affects the attitude towards technology.</td>
<td>Not Supported</td>
</tr>
<tr>
<td>H2 – trust of consumers in the suppliers will lead to a positive attitude towards technology.</td>
<td>Supported</td>
</tr>
<tr>
<td>H3 - loss of control will have a negative effect on the attitude.</td>
<td>Not Supported</td>
</tr>
<tr>
<td>H4 – higher perceived fairness will lead to a positive attitude towards technology.</td>
<td>Supported</td>
</tr>
<tr>
<td>H5 – higher perceived sustainability will lead to positive attitude towards technology.</td>
<td>Supported</td>
</tr>
<tr>
<td>H6 - higher compatibility with lifestyle and appliances will lead to a positive attitude towards technology.</td>
<td>Not Supported</td>
</tr>
<tr>
<td>H7 - effective feedback on energy consumption can lead to positive attitude towards technology.</td>
<td>Supported</td>
</tr>
<tr>
<td>H8 – stronger feelings of responsibility would lead to stronger personal norms</td>
<td>Not Supported</td>
</tr>
<tr>
<td>H9 – positive attitude towards smart hems would lead to higher intention to buy.</td>
<td>Supported</td>
</tr>
<tr>
<td>H10 – subjective norms positively influence intention to buy.</td>
<td>Supported</td>
</tr>
<tr>
<td>H11 – higher perceived behavioural control leads to stronger intentions to buy.</td>
<td>Supported</td>
</tr>
<tr>
<td>H12 – stronger personal norms lead to higher intentions to buy.</td>
<td>Supported</td>
</tr>
<tr>
<td>H13a – knowledge about the system can have significant effect on the attitude.</td>
<td>Not Supported</td>
</tr>
<tr>
<td>H13b – knowledge about the system can have significant effect on intention to buy.</td>
<td>Supported</td>
</tr>
<tr>
<td>H14a – age has significant effect on the attitude, subjective norms, perceived behavioural control, personal norms and intention to buy.</td>
<td>Partly Supported</td>
</tr>
<tr>
<td>H14b – gender has significant effect on the attitude, subjective norms, perceived behavioural control, personal norms and intention to buy.</td>
<td>Supported</td>
</tr>
<tr>
<td>H14c – Housing condition has significant effect on the attitude, subjective norms, perceived behavioural control, personal norms and intention to buy.</td>
<td>Partly Supported</td>
</tr>
<tr>
<td>H14d – Education has significant effect on the attitude, subjective norms, perceived behavioural control, personal norms and intention to buy.</td>
<td>Not supported</td>
</tr>
</tbody>
</table>
6.2. Limitations

The theoretical model built in this research is composed of ethical values, technological characteristics and constructs as identified from the literature. Due to bounded rationality and time constraints, the number of articles relevant articles reviewed by the researcher is constrained. Also, accessing all the values of the individuals is impossible due to the diversity of opinions. So, the resulting model is based on best knowledge of the researcher and it is possible that some characteristics/values have not been included in the model.

For the constructs in the theoretical model, measures were developed based on the theory. Much later in the phase of data collection, it was realised that not all the constructs had the required 3 item measures. This was due to the limited knowledge of the researcher in data collection and statistical analysis procedures. It is possible to overcome the limitations of less than 3 item measures by having a relatively large sample size (>500). But, even the requisite sample size was not achieved. This less than 3 item measures per construct may have had an impact on EFA results with the PFA method not converging for required number of factors.

As it is with most studies involving the Theory of Planned Behaviour, Norm Activation Model and other behavioural models, the data that was collected was self-reported by the respondents. This has been known to cause bias in data as individuals have a tendency to portray socially desirable attitudes and intentions.

Another limitation of the data was the sampling technique used. Due to time and monetary constraints, a convenience sampling was used for data collection. The main problem with a convenience sample is that it can lead to the under-representation or over-representation of particular groups within the sample. This was seen in the data as the collected sample was skewed young with mainly a bachelor or master degree and living in rented accommodations.

Finally, due to time constraints only intention to buy/use the technology was studied. Actual behaviour could not be studied i.e. a longitudinal study was not performed to find if intentions did really lead to a behaviour as expected.
6.3. Contribution

In this research, we have studied the acceptance of smart HEMS through an extensive model which incorporates ethical values and technological characteristics with the constructs of rational and normative decision making model. To the researcher’s best knowledge, this is the first time that such an integration is carried out in the context of smart HEMS. This research provides validation on the applicability of Theory of Planned behaviour to studying behaviour. The results also provide more evidence that constructs of the Normative Activation Model should be included in the TPB model especially when studying the behaviours which are environmentally oriented. This research contributes to the increasing literature in the field of technology acceptance. The results of this study improve our understanding of what motivates the intention of the users when selecting the technology. As lots of smart energy system technologies are very similar, the model developed in this research and the results from it can serve as a great backdrop for future research on the acceptance of these technologies.

6.4. Practical Relevance

Understanding the relevant factors for acceptance of technology by end users can be useful for the companies developing the technology. The most important factor is Sustainability as it has the strongest effect on intention when compared to other factors. Thus, companies should consider designing the system to allow for effective and efficient utilisation of energy which would increase its sustainability value. From the results, it is clear that feedback is important to users. So the companies would benefit from designing system which provides effective feedback which would be basis for improving energy usage. It needs no mention that companies should develop trust among their customers as it plays an important role in developing a positive attitude towards their technology. This can be achieved in many ways like by providing great service, delivering consistent quality, displaying transparency, incorporating state-of-the-art security features and other such actions. Another factor that is relevant is the fairness as perceived by the users with regards to distribution of benefits and drawbacks of using the technologies. Companies and governments can increase the perceived fairness by providing additional incentives to individuals for installing such systems. Knowledge of the system does have an effect on the intention of the potential users. The companies or even the government can, thus, increase the acceptance of the technology by increasing awareness about it and its advantages.
6.5. Future Research

As mentioned in the limitations, it is possible that not all the variables have been identified and included in the model. It is also possible that some of the variables that have been included are not relevant in future. Further research could thus extend/decompose this model and carry out a more extensive study of user intentions to buy the smart HEMS technology.

A more carefully selected representative sample (using probabilistic sampling methods) can provide further insights into the applicability of the model. The research can also be extended by expanding the audience and to verify if cultural differences have an effect on the acceptance of technology. Another avenue for research that can be done is to see if the nature of housing (house, apartment, studio, etc.) has an effect on the intentions to buy the technology.

This study focused on the acceptance of only smart Home Energy Management Systems. Future studies could apply the model developed in this research to other technologies included in the smart energy system paradigm like the smart meters, smart grids, etc. Smart HEMS is a relatively new technology and thus a more comprehensive investigation on intentions can be conducted when the technology reaches a critical mass. Though there is substantial empirical support for the causal link between intention and behaviour (Taylor and Todd, 1995; Venkatesh and Davis, 2000), a longitudinal study in this domain can only further enhance our understanding of acceptance of technology.
7. Conclusion

This research began with objective of determining the relative influence of ethical values on the acceptance of smart HEMS by the end users. For determining the influence of ethical values, a theoretical model was developed and was tested once to explain intentions to buy smart HEMS technology.

What is the relative influence of ethical values on the acceptance of smart home energy management systems by end users?

The final model developed in this research proved useful in predicting intentions to buy the smart home energy management systems. The developed model fit the data relatively well and explained variance of the dependent variable (intention) was on the higher side (63%). Among the discussed ethical values sustainability, trust and fairness were found to affect (significantly) the intention to buy indirectly through attitude of the users. The following table provides the total effect of these values on the intention,

<table>
<thead>
<tr>
<th>Ethical Values</th>
<th>Intention To Buy/ Use</th>
</tr>
</thead>
<tbody>
<tr>
<td>Sustainability</td>
<td>0.194</td>
</tr>
<tr>
<td>Trust &amp; Fairness</td>
<td>0.173</td>
</tr>
</tbody>
</table>

What behavioural models are relevant for studying the end user’s acceptance of smart home energy management systems?

Out of the rational behavioural models, Theory of Planned Behaviour (TPB) was chosen because it has more explanation power than Theory of Reasoned Action (TRA), is parsimonious as compared to the Unified Theory of Acceptance and Use of Technology (UTAUT) and performs considerably well than Technology Acceptance Model (TAM) in predicting intentions and behaviour. Though, TPB also has wider applicability it has limitations as it does not include normative influences. To increase the explanatory power TPB was extended using constructs from the Norm Activation Model (NAM). The inclusion of personal norms from NAM increased the explanatory power of the model by 10.5%.
What are ethical values relevant to the end user's acceptance of smart home energy management systems?

From the theory, five ethical values were identified that could affect the acceptance of the HEMS by end users. Privacy, Trust, Autonomy, Fairness, and Sustainability were all predicted to affect the intention to buy/use HEMS through attitude towards the technology. From the results, we find that from these five values only Trust, Fairness and Sustainability have a significant effect on the attitude towards the technology. Among these sustainability has the strongest effect on the attitude followed closely by Trust & Fairness.

![Figure 14 Ethical values relevant to acceptance of smart HEMS](image)

What are the technological characteristics that are relevant for end user's acceptance of smart home energy management systems?

The technological characteristics of Feedback and Compatibility were identified from existing research to have an effect on the acceptance of the HEMS. Among these, Feedback was found to have a significant effect on forming an attitude towards the technology. Better the feedback provided by the system on energy consumption better the attitude towards the technology.

![Figure 15 Technological characteristics relevant to acceptance of smart HEMS](image)
8. Bibliography


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Appendix A: Behavioural Models

Rational Decision Making Models

Theory of Reasoned Action

Developed by Fishbein and Ajzen, the Theory of Reasoned Action aims at explaining and predicting the volitional behaviour of an individual (Ajzen & Fishbein, 1969, 1980). Theory of Reasoned Action (TRA) is based on the assumptions that individuals are rational decision makers and that they make systematic use of the information available to them. TRA provides with a relationship between the norms, attitudes, intentions and behaviour. According to Ajzen and Fishbein (1980), behaviour is determined by the intention to behave which in turn is affected by individual’s attitude towards behaviour and subjective norms associated with the behaviour. A schematic representation of the theory is given below in the Figure 16. As can be seen in the Figure 16, the behavioural intention is affected by the normative component and attitudinal components.

![Figure 16 Theory of Reasoned Action, reproduced from Ajzen and Fishbein (1980)](image)

Attitude towards Behaviour

An individual’s attitude towards the behaviour is determined by beliefs which lie beneath the individual’s attitude towards a given behaviour are termed as *behavioural beliefs*. These beliefs are concerned with the outcomes or evaluation of the outcomes of the behaviour. Thus, a belief that
a positive outcome will result from adopting a behaviour will lead to a positive attitude towards the behaviour when as compared towards a belief of negative outcome.

**Subjective Norms**

Subjective norm, the second component which determines behavioural intention, refers to the perception of individual regarding the societal pressures to perform (or not perform) the behaviour under consideration. Beliefs underlying the subjective norms are referred to as the normative beliefs. Subjective norms of individual are derived from the fact whether referents important to the individual approve or disapprove of the behaviour and the motivation of the individual to comply with these referents. Thus, a positive subjective norm results from important referent believing that certain behaviour should be performed and high motivation of the individual to comply with the referent.

**From Intention to Behaviour**

As discussed before, intentions are the immediate precursors to the behaviour. But, the strength of relationship between intention and behaviour is affected by the stability of intentions and degree of correspondence between intention and behaviour (Ajzen & Fishbein, 1980). Intentions are time bound i.e. they can change over time and therefore, a long gap between measurement of intention and observation of behaviour can lead to less accurate prediction of the relationship. Thus, Ajzen and Fishbein (1980) suggest that the intentions should be measured as close to observation of behaviour as possible. They also comment that group (aggregate) intentions are generally more stable than the individual intentions as individual intentions are more likely to be affected by unexpected events. For an accurate prediction, Fishbein & Middlestadt (1989) recommend that the measures of intention and behaviour should correspond. This correspondence must also take into account whether the target behaviour is single-action criterion (specific behaviour) or multiple-choice criterion (one out of multiple).

**Review**

The TRA has found broad applicability in measuring intentions and behaviours. Study of volitional behaviour using TRA spans, but is not limited to, from reporting of alien abductions (Patry & Pelletier, 2001), coupon usage (Bagozzi et al., 1992; Shimp & Kavas, 1984), fast food consumption (Bagozzi et al., 2000), condom usage (Albarracín et. al, 2001), buying online groceries (Hansen et al., 2004) to user acceptance of expert systems (Liker & Sindi, 1997), studying moral behaviour
(Vallerand et. al, 1992) and predicting unethical behaviour (Chang, 2013). The theory has been tested rigorously and has been found to be robust when predicting intentions and behaviour under volitional control (Davis et al., 1989; Manstead et al., 1983).

Theory of Reasoned Action has its limitations in the form of its ability to predict behaviour falls drastically when extended beyond its boundaries i.e. limited control over behaviour, intentions are not stable, etc. (Liker & Sindi, 1997; Tlou, 2009). As it is focused mainly on the rational decision making constructs, it precludes the subjective and irrational factors such as values, emotions, moral considerations which may affect the decision making. Kippax & Crawford (1993) also express doubts about the linearity of the model as it does not explain the risky behaviour pursued by individuals (e.g. risky sexual behaviour – not using condoms) even when they espouse appropriate attitudes, norms and beliefs. Some researchers like Langdridge et al.(2007) have questioned the sufficiency of the theory as according to them intention, attitude and norms are not the only factors affecting the behaviour. Many researchers (see Greve, 2001) have criticised that the TRA is not a good theory because it is not falsifiable, but others (see Trafimow, 2009) refute their claim about the theory not being falsifiable.
Technology Acceptance Model

With the booming technological growth in the 1970s and the increasing failures of system adoption in many industries, a lot of researchers concentrated on developing the models for explaining and predicting system use. But most of these models failed to produce reliable results for explaining system acceptance or rejection (Chuttur, 2009). Following this, in his doctoral thesis at the MIT Sloan School of Management, Fred Davis proposed the technology acceptance model in 1980. According to him, the use of a system can be predicted or explained by the motivation of the user which is affected by the features and capabilities of the actual system.

![Conceptual Framework for TAM](image17.png)

**Figure 17 Conceptual Framework for TAM, reproduced from Davis (1989)**

Based on the Theory of Reasoned Action and other behavioural research, Davis further refined his conceptual framework to propose the Technology Acceptance Model as shown in Figure 17. According to Davis, the user’s motivation to use a system is affected by three factors: Perceived Usefulness, Perceived Ease of Use and Attitude towards Use. The Attitude of the individual towards the system was hypothesised to be the major determinant of the whether the user will eventually accept or reject the technology. The attitude, in turn, is preceded by the constructs of Perceived Usefulness and Perceived Ease of Use, with the ease of use having a direct influence on the usefulness of the system. Finally both of these beliefs were hypothesised to be affected by external variables like system characteristics as shown in Figure 18.

![Technology Acceptance Model](image18.png)

**Figure 18 Technology Acceptance Model, reproduced from Davis (1989)**
Perceived Ease of Use

Perceived ease of use (EOU) refers to the degree to which a person believes that using a particular system would be free of effort (Davis, 1989). In the model, EOU influences both attitude and Perceived Usefulness. A system which is easier to use impacts the user’s sense of self efficacy. High self-efficacy leads to a strong belief in the ability to use system leading to a more positive attitude towards the system (Bandura, 1982). Also, when the system is easy to use it will reduce the effort of the person improving his performance i.e. Perceived Usefulness. EOU is affected by external variables like system characteristics and attributes.

Perceived Usefulness

Perceived Usefulness (USEF) can be defined as the degree to which a person believes that using a particular system would enhance his or her job performance. It is a cognitive evaluation of how adopting a new piece of technology will influence one’s job performance (Ducey & Coover, 2016). USEF influences one’s attitude toward using a new piece of technology because people form positive attitudes toward new technology that they believe will positively affect their job performance. In addition, perceived usefulness directly impacts behavioural intention to use the technology because people form intentions to use a device that they believe will increase their job performance, regardless of their personal feelings (i.e., EOU) toward the technology, because people are motivated to obtain performance-contingent rewards (e.g., promotions, raises).

Attitude towards Use

Attitude refers to the degree of evaluative affect that an individual associates with using the target system in his or her job. The attitude towards a target system, as discussed before, affected by the individual’s perception of the usefulness and ease of use of the system.

Review

By any measure, TAM qualifies as a remarkable accomplishment, even reaching the status of a paradigm of sorts. The number of citations of Davis et al. (1989) alone is over 700 to date, which is a very high number indeed for an article in an applied field (Bagozzi, 2007). And the stream of research in the TAM tradition is impressive in its volume and scope (Lee et al., 2003).

The main strength of TAM is its parsimony (Bagozzi, 2007). TAM has become one of the most widely used models in IS, in part because of its simplicity and that it is easy to understand (King
& He, 2006). With meta-analysis of 88 TAM studies involving more than 12,000 observations, King & He (2006) concluded that The TAM measures (PU, U, and BI) are highly reliable and may be used in a variety of contexts. The influence of perceived usefulness on behavioural intention is profound, capturing much of the influence of perceived ease of use (King & He, 2006). Legris et al. (2003) conducted a study of 22 empirical articles and concluded that the model have proven to be of quality and to yield statistically reliable results.

Parsimony has also been an Achilles’ heel for TAM. In favouring a simple model, researchers have overlooked essential determinants of decisions and action, and turned a blind eye to inherent limitations in TAM (Bagozzi, 2007). Bagozzi (2007) also questions the theoretical link of intention-actual use and observed that the behaviour should not be terminal goal but a more fundamental one. Intention to use may not be an actual representation of the actual use, because the time period between the intention and adoption can be full of uncertainties and other factors may affect the decision making (R. Bagozzi, 2007; Chuttur, 2009). Benbasat and Barki (2007) suggest that the independent attempts by several researchers to expand TAM in order to adapt it to the constantly changing IT environments has led to a state of theoretical chaos and confusion. Legris et al. (2003) claim that, together, TAM and TAM2 account for only 40% of a technological system's use.
Unified Theory of Acceptance and Use of Technology

Through their research, Venkatesh et al. (2003) concluded that since a multitude of frameworks are available to researchers for predicting the acceptance of IS technologies, researchers may choose a familiar/ favourite model and neglect important constructs from alternative model. Thus, they felt there was a need to reach a unified view of users’ technology acceptance. Following this, they reviewed and compared 8 models that have been frequently used to study consumer acceptance (see table 10). Based on the review they formulated the Unified Theory of Acceptance and Use of Technology (UTAUT) model.

Table 14 Models used for Building UTAUT

<table>
<thead>
<tr>
<th>Model</th>
<th>Authors</th>
</tr>
</thead>
<tbody>
<tr>
<td>Theory of Reasoned Action</td>
<td>Fishbein and Ajzen</td>
</tr>
<tr>
<td>Technology Acceptance Model</td>
<td>Davis</td>
</tr>
<tr>
<td>Motivational Model</td>
<td>Davis et al.</td>
</tr>
<tr>
<td>Theory of Planned Behaviour</td>
<td>Ajzen</td>
</tr>
<tr>
<td>Combined TAM and TPB</td>
<td>Taylor and Todd</td>
</tr>
<tr>
<td>Model of PC Utilization</td>
<td>Thompson et al.</td>
</tr>
<tr>
<td>Innovation Diffusion Theory</td>
<td>Moore and Benbasat</td>
</tr>
<tr>
<td>Social Cognitive Theory</td>
<td>Compeau and Higgins</td>
</tr>
</tbody>
</table>

According to Venkatesh et al. (2003), four key constructs viz. performance expectancy, effort expectancy, social influence, and facilitating conditions are significant direct determinants of intention or usage. They also posited that Gender, Age, experience and voluntariness of use act as moderating variables to mediate the impact of the four key constructs on the intention or actual usage, as shown in Figure 19.

Performance Expectancy

Performance Expectancy is defined as the degree to which an individual believes that using the system will help him or her to attain gains in job performance. There are five constructs from the different models on which the UTAUT finds its basis that pertain to Performance Expectancy. These are Perceived Usefulness (TAM/TAM2 and C-TAM-TPB), Extrinsic Motivation (MM), Relative Advantage (IDT), and Outcome Expectations (SCT) (Venkatesh et al., 2003). This
construct, within each individual, was the strongest predictor of intention and remained significant at all points of measurement in both voluntary and mandatory settings.

Figure 19 UTAUT, Reproduced from Venkatesh et al. (2003)

**Effort Expectancy**

Effort Expectancy is defined as the degree of ease associated with the use of the system. Three constructs from the existing models capture the concept of effort expectancy: Perceived Ease of Use (TAM/TAM2), complexity (MPCU), and Ease of Use (IDT). There is substantial similarity among these construct definitions and measurement scales. Effort-oriented constructs are expected to be more salient in the early stages of a new behaviour, when process issues represent hurdles to be overcome, and later become overshadowed by instrumentality concerns (Venkatesh et al., 2003). The construct in each individual model was significant in both voluntary and mandatory settings.

**Social Influence**

Social influence is defined as the degree to which an individual perceives that important others believe he or she should use the new system. Social influence as a direct determinant of behavioural intention is represented as Subjective Norm in TRA, TAM2, TPB/DTPB and C-TAM-TPB, Social Factors in MPCU, and Image in IDT (Venkatesh et al., 2003). The comparison between models found that this construct behaved similarly; it is insignificant in voluntary contexts and becomes significant when use is mandatory.
**Facilitating Conditions**

Facilitating conditions are defined as the degree to which an individual believes that an organizational and technical infrastructure exists to support use of the system. This definition captures concepts embodied by three different constructs: Perceived Behavioural Control (TPB, TAM, and TRA), Facilitating Conditions (MPCU), and compatibility (IDT). In the UTAUT model it is assumed that when Performance Expectancy and Effort Expectancy are included in the model, Facilitating Conditions becomes insignificant in predicting Usage Intention, but does have an effect on usage beyond that explained by behavioural intentions (Venkatesh et al., 2003).

**Moderators**

The constructs of the UTAUT model are also build up with determinants that have a moderating role in predicting user acceptance viz. Gender, Age, Experience and Voluntariness of Use. The influence of performance expectancy on behavioural intention is hypothesized to be moderated by gender and age, while that of effort expectancy on behavioural intentions is hypothesized to be moderated by gender, age, and experience. On other hand, influence of social influences on behavioural intentions is hypothesized to be moderated by gender, age, voluntariness and experience while that of facilitating conditions on usage is hypothesized to be moderated by age and experience.

**Review**

The model has been primarily used for technology adoption and acceptance research in the areas of e-government, e-banking, e-learning and e-commerce. With a systematic and comprehensive review of 174 articles appearing since 2004, Williams et al. (2011)found that general purpose systems and specialized business systems were examined in the majority of the articles using the UTAUT. The analysis also indicated that cross-sectional approach, survey methods, and structural equation modelling analysis techniques were the most explored research methodologies whereas SPSS was found to be the largely used analysis tools. Moreover, the weight analysis of independent variables indicates that variables such as performance expectancy and behavioural intention qualified for the best predictor category. Meta-analytic review of UTAUT conducted by Dwivedi et
al. (2011) concluded that that most of the relationships that exist between the constructs of the model are consistently significant.

Numerous studies have been carried out to validate and verify the robustness of the UTAUT model. Oshlyansky et al. (2007) proposed using the UTAUT model as a tool to verify human-computer interface (HCI) methods and tools cross-culturally. They conducted a survey across nine countries, which included Czech Republic, Greece, India, Malaysia, New Zealand, Saudi Arabia, South Africa, United Kingdom, and United States. The results showed that the UTAUT tool is robust enough to withstand translation and to be used cross-culturally. Knutsen (2005) used a subset of the UTAUT to explore the relationship among expectations related to performance of a new mobile service, efforts needed to utilize new mobile services, and how these constructs affect attitudes toward new mobile services. The empirical results significantly verified the relationship between PE-EE and attitude as well as between EE-PE. Carlsson et al. (2006) adopted UTAUT to explain the mobile device adoption found that that performance expectancy and effort expectancy had a strong direct effect on intention to use mobile devices and such an effect was weakened when attitude was added to the model, which indicated that attitude explains part of the intention to use the mobile device.

Bagozzi (2007) criticised the UTAUT model stating that even though it is well-intentioned and well meaning, it has helped in making technology adoption studies chaotic by presenting 41 independent variables for predicting intentions and 8 variables for predicting behaviour. Raaij & Schepers (2008) criticized the UTAUT as being less parsimonious. They also called the grouping and labelling of items and constructs problematic because a variety of disparate items were combined to reflect a single psychometric construct. A systematic review conducted by Williams et al. (2011) revealed that many papers which cited the UTAUT article did not use the theory. They state that despite the apparently high numbers of citations, the level of actual UTAUT use in practice is somewhat lower than the citation level may suggest raising the possibility that the original model may not have suited all circumstances and alternate research methods were required. They found that the current research on UTAUT constructs are impacted upon by many external variables across different studies which was relatively surprising outcome as UTAUT purports to be a unified theory, being created by the mapping together of numerous variables from eight established theories and models.
Normative Models

Value-Belief-Norm Model

Value-Belief-Norm model developed by Stern (2000b) explicitly includes and specifies which values (unlike NAM) can be used to explain prosocial behaviour in environmental context. Value-Belief-Norm (VBN) model links value theory (e.g., S. Schwartz, 1992), environmental beliefs (Dunlap & Van Liere, 2008) and the NAM into a mediation model that moves from relatively stable values and beliefs, to more specific beliefs that eventually will lead to pro-environmental action (Dietz et al., 2005). Graphically the model is represented in Figure 20.

Like the NAM, personal norms (PN) to take pro-environmental action are activated by beliefs about the adverse consequences for valued objects (AC) and by the beliefs of one’s ability to reduce this threat (AR). AC and AR beliefs depend on environmental concerns, which are general beliefs about human-environment relationships. At the beginning of the causal chain are egoistic, altruistic and biospheric value orientations that, through environmental concerns, influence AC, AR and PN and consequently Environmentally Significant Behaviour (ESB) as shown in Figure 20.

Values

The first element of the VBN theory is based on a person’s values. Values are considered very stable and unlikely to change (Schwartz, 1977). Stern (2000b) divided the values component into three separate domains: biospheric values, altruistic values, and egotistic values. Biospheric values are attitudes and beliefs that support different species and natural environments (P. C. Stern,
2000b). However, according to Stern (2000b) very little empirical evidence has been found to support these values. Even then, Stern incorporated them into the model in order to gain a better understanding of a person’s perceptions of the natural environment.

Altruistic values are concerned with the well-being of other people Stern (2000b). Altruism is a term to describe attitudes and behaviours that are considered unselfish and are for the greater common good. The altruistic value component in the VBN theory was adapted from Schwartz’s (1977) Norm-Activation Theory. Egotistic values (i.e., self-interest values), along with altruistic values, are based on environmental concern (P. Stern et al., 1999). Steg et al. (2005) along with many other researchers agrees that to support many pro-environmental movements, the individual has to restrain his egoistic tendencies.

Beliefs

Along the causal chain of the model, the first component under beliefs which is affected by the values is the ecological worldview. The ecological worldview component of the model is a measure of the New Ecological Paradigm (NEP), which was developed and revised by R. E. Dunlap and his colleagues (Dunlap & Van Liere, 2008). The New Ecological Paradigm scale is a measure of endorsement of a “pro-ecological” world view.

Moving across the causal chain of the VBN theory model, adverse consequences for valued objects (AC) refers to the threats that human-environmental interactions pose to valued objects (Stern et al., 1999). The awareness of adverse consequences to the environment that humans pose, will often lead to perceptions of one’s ability to reduce the negative consequences leading to the next link in the chain, perceived ability to reduce the threat (AR).

Personal Norms

Researchers have defined personal norms as a feeling of moral obligation to take action (P. C. Stern, 2000b). According to the VBN theory values, ecological worldviews, adverse consequences, and perceived ability to reduce threats activate personal norms. Personal norms, in addition to altruistic values, are the most important and corroborated components of the VBN theory.

Environmentally Significant Behaviour

Stern distinguishes four types of pro-environmental actions that the VBN model is able to explain, namely environmental activism (e.g., volunteering to environmental organisations), non-activist
behaviours in the public sphere (e.g., acceptance of environmentally friendly policies), private sphere behaviours (e.g., recycling) and behaviours in organisations (e.g., designing environmentally benign products)

**Review**

Over the last decade, there has been an increasing amount of empirical support for the VBN model as well. These studies support the VBN model to explain a diversity of environmental significant intentions and behaviours, such as pro-environmental political behaviour (Joireman et al., 2001), willingness to reduce car use (Eriksson et al., 2006), general pro-environmental behaviour (Nordlund & Garvill, 2002), acceptability of energy policies (Steg et al., 2005), consumer behaviour, environmental citizenship, and willingness to sacrifice (Stern et al., 1999), and multinational pharmaceutical corporations (Andersson et al., 2005). Depending on the type of behaviour, evidence has shown that the VBN model explains 19 per cent to 35 per cent of its variance (Stern et al., 1999). The VBN model has shown that values frame attitudes and provide standards and could therefore be seen as an overall influence on intentional behaviour (Derckx, 2015).

The VBN theory has its own set of shortcomings. Much like the other theories discussed in the text, the theory relies on self-report and hence there is a discrepancy between reported and actual behaviour (Davis, 2014). Another criticism of this model is that all of the determinants remain at the level of the individual (Oreg & Katz-Gerro, 2006). The VBN theory is similar to Ajzen’s (1991) theory of planned behaviour. The two theories have been compared by Kaiser et al. (2005) with respect to environmentalism. The results of Kaiser et al. (2005) indicated that the theory of planned behaviour was more accurate in explaining conservation behaviour, even though the VBN theory is superior in terms of the model structure. A similar study carried out by López-Mosquera and Sánchez (2012) to explain willingness to pay for a suburban park found similar results indicating that, both in terms of the variance explained and the different comparison indices, the TPB model has more predictive power than the VBN model.
Appendix B: Survey Questionnaire

Hi, I am Smitesh Jain. As part of a M.Sc. Thesis Project at TU Delft, I am carrying out research to study what factors affect the consumer's intention to buy Smart Home Energy Management Systems.

The survey will take about 5-10 minutes of your time. All the responses are collected anonymously and will be used for academic purposes only.

For any questions, please contact me at S.P.Jain@student.tudelft.nl

About Smart Home Energy Management Systems

Smart Home Energy Management Systems (HEMS) are composed of many components like smart meter, energy storage batteries, and central controller. This system monitors real time consumption of electricity and can control at what time different appliances like heating system, washing machine, etc. are connected. In general, the aim of HEMS is to increase energy efficiency and reduce electricity consumption for households.

Do you have a smart HEMS or its components installed at your house?*
Yes  No

How familiar are you with Smart HEMS technology or its components?*
(Unfamiliar)  1  2  3  4  5 (Familiar)

Please indicate the extent to which you agree/ disagree with the following statements

<table>
<thead>
<tr>
<th>Statement</th>
<th>Disagree</th>
<th></th>
<th>Agree</th>
</tr>
</thead>
<tbody>
<tr>
<td>I believe using Smart HEMS would fit my lifestyle.*</td>
<td>1</td>
<td>2</td>
<td>3</td>
</tr>
<tr>
<td>A product that fits well with my lifestyle is good.*</td>
<td>1</td>
<td>2</td>
<td>3</td>
</tr>
<tr>
<td>I believe that Smart HEMS should be compatible with existing appliances in my house.*</td>
<td>1</td>
<td>2</td>
<td>3</td>
</tr>
<tr>
<td>A product that is compatible with existing products in my house is good.*</td>
<td>1</td>
<td>2</td>
<td>3</td>
</tr>
<tr>
<td>I believe using Smart HEMS would allow energy companies to control my electricity use.*</td>
<td>1</td>
<td>2</td>
<td>3</td>
</tr>
<tr>
<td>Statement</td>
<td>1</td>
<td>2</td>
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<tr>
<td>--------------------------------------------------------------------------</td>
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<tr>
<td>I believe Smart HEMS can control my appliance usage.*</td>
<td></td>
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<tr>
<td>I think lack of control on electricity or appliance use is a bad thing.*</td>
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<td></td>
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<tr>
<td>Smart HEMS should transfer consumption reports automatically to my computer/laptop/mobile.*</td>
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<td></td>
<td></td>
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<tr>
<td>My consumption data must be illustrated graphically.*</td>
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<tr>
<td>Smart HEMS should be able to provide feedback on individual domestic appliances.*</td>
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<tr>
<td>Smart HEMS should be able to forecast my consumption for coming months.*</td>
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<tr>
<td>A product that provides useful feedback is good.*</td>
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<td></td>
<td></td>
</tr>
<tr>
<td>I believe that all my personal information will be protected.*</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>I believe that all my data on energy consumption will be protected.*</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>I believe that using Smart HEMS can violate my privacy.*</td>
<td></td>
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<td></td>
</tr>
<tr>
<td>I trust the companies providing the Smart HEMS technology.*</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>I think buying Smart HEMS is a good idea.</td>
<td></td>
<td></td>
<td></td>
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<tr>
<td>In my opinion, it is desirable to buy Smart HEMS*</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>People who are important to me think that I should buy Smart HEMS.*</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>People whose opinions that I value prefer that I buy Smart HEMS.*</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>I would find it difficult to buy a Smart HEMS.*</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>The decision to buy a Smart HEMS is beyond my control.*</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>I have the resources to buy a Smart HEMS.*</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>My contribution to energy problems is negligible.*</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
I feel jointly responsible towards the depletion of energy resources.*  1 2 3 4 5
I feel responsible towards the environment.*  1 2 3 4 5
I feel responsible to do something to reduce energy usage.*  1 2 3 4 5
I believe that Smart HEMS products should be produced in a sustainable manner.*  1 2 3 4 5
I would like to prevent environmental degradation.*  1 2 3 4 5
I would use technologies which minimize environmental impact.*  1 2 3 4 5
I believe that using Smart HEMS contributes to sustainability.*  1 2 3 4 5
I believe that using Smart HEMS will contribute in protecting the environment.*  1 2 3 4 5
I would feel guilty if I didn’t buy Smart HEMS.*  1 2 3 4 5
I feel a moral obligation to buy Smart HEMS.*  1 2 3 4 5
I intend to use Smart HEMS.*  1 2 3 4 5
I expect to buy Smart HEMS.*  1 2 3 4 5
I want to buy Smart HEMS.*  1 2 3 4 5

If you buy the Smart HEMS, what do you think of the distribution of benefits and drawbacks with respect to yourself and others?*

*Explanation - Entire society along with you benefits from you installing home energy management system (in terms of energy savings, increased energy efficiency and less pollution), but the drawbacks of installing it may be experienced only by you (cost, privacy, security). How do you feel about this?*

(Unfair)  1 2 3 4 5 (Fair)

Demographic Questions
1. Gender - Male Female Unspecified
2. Age - 18-24 25-34 35-44 45-54 55-64 65+
3. Education - Some college credit, no degree
   High school graduate, Diploma (for example: GED)
Trade/ Technical/ Vocational Training
Associate Degree
Bachelor’s Degree
Master’s degree
Professional Degree
Doctorate

4. Country of Birth - _______________________________________

5. Country of Residence - _____________________________________

6. Housing Condition- Rent  Own  If Other, Please specify ______________
Appendix C: Smart Energy Systems

EnergyPLAN, a research group in Denmark, defines the Smart Energy System as a system which consists of 100% renewable energy, utilises bioenergy sustainably, maximises the synergies in the system to improve efficiency and reduce costs, and is affordable (EnergyPLAN, 2017). Nizamic (2016) considers a smart energy system as an ICT system that supports energy consumption reduction as well as integration of other sustainability interventions or systems. The definition provided by Nizamic (2016) focuses only on the information technology part of the entire energy system and neglects rest of it.

Mathiesen et al. (2011) define smart energy systems as a smart combination of gas, thermal and electricity grids to allow coordination between them by identifying synergies between them and achieve optimal efficiency for the entire system as well as the individual components. Smart energy systems must include new technologies and require infrastructure to be able to create the required flexibility in the energy system.

Figure 21 provides with a brief overview of various components that are currently considered as part of the smart energy system. Considering the fact that smart energy system is composed of multiple subsystems, it would be prudent to study the acceptance of each component separately rather than the whole system at once (as the involvement of consumers varies greatly depending on the component in consideration). For this purpose, the focus of this report would be on studying the acceptance of Smart Home Energy Management Systems (HEMS), which are a part of the smart energy control systems in the Figure 21.

Along with economic, sustainability and efficiency, smart energy systems offer a myriad of other advantages over the existing grid. They allow for an active participation by consumers, can accommodate all kinds of electric production and storage grid points, create a market for new products and services, improve the asset utilisation and operating efficiency and provide resilience to power disturbances (Elzinga, 2011).
Figure 21 Smart Energy Systems, adapted from Lever (2015)
Appendix D: Smart Grids

Smart Grids, according to the EU, is an intelligent electric network delivers electricity supply in an efficient, economic and sustainable manner to all sets of users including generators, consumers or those who do both (European Commission, 2011). The department of energy of United States on the other hand concentrates on the aims of the smart grid and describes it as network which has the capability to absorb power fluctuations, supports active consumer participation, provides for 21st century electricity needs while providing efficient operations and helping creation of new markets, products, and services (U. S. Department of Energy, 2012). Thus, basic concept behind the Smart Grids is to add control, monitoring and analysis, so that electricity can be moved around the grid more efficiently and economically (NEMA, n.d.).

Figure 22 Smart Grid, reproduced from CLP Power Corporation, 2016