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MASTER

Reducing energy consumption in office buildings using energy meter data

determining change in energy consumption behavior of employees through feedback on their energy consumption

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Award date:
2017

Link to publication

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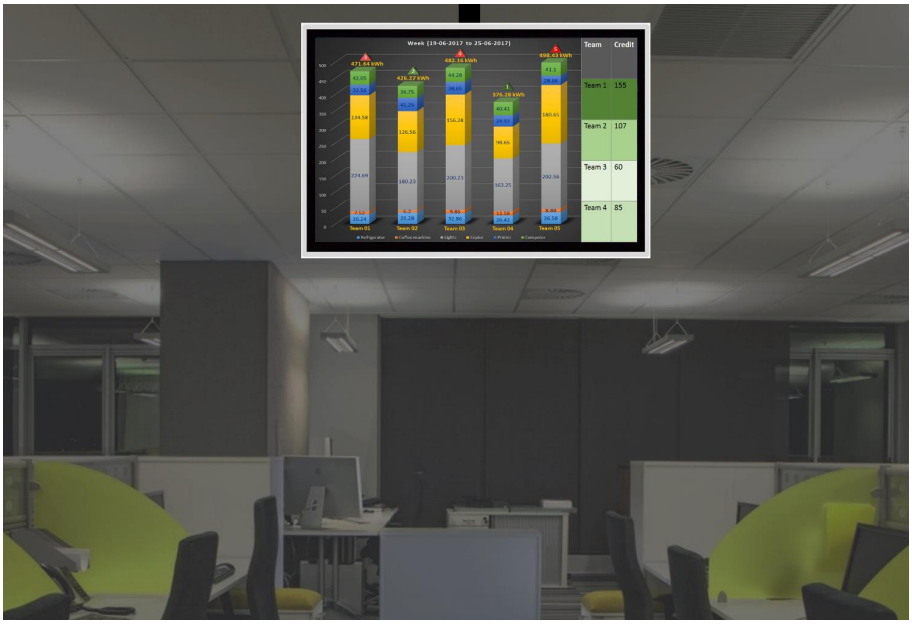

Reducing energy consumption in office buildings using energy meter data

Determining change in energy consumption behavior of employees through feedback on their energy consumption

Master Graduation Thesis

Construction Management and Engineering

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Master Thesis

"Reducing energy consumption in office buildings using energy meter data"

Determining change in energy consumption behavior of employees through feedback on their energy consumption

Colophon

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Report	Graduation Thesis
Status	Final

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Preface

This report is the output of my graduation project which is the final part of Master program Construction Management and Engineering (CME) at the Eindhoven University of Technology (TU/e). The study aims to investigate the possibility of reducing energy consumption in an office-type workplace by bringing change in the energy consumption behavior of employees using their energy consumption data.

Studying at TU/e as an international student was already a precious experience of my life and carrying out this research has added valuable component in that experience. During the master course studying in various courses was an enlightening experience, especially the course on Smart Cities. Studying various aspects related to smart city in terms of smart energy, smart mobility, smart governance was the triggering point for my motivation to work on this topic.

Firstly, I would take this opportunity to thank dr. Q. Han for her extreme support and guidance during all the stages of my thesis. Clarifying my doubts along with her valuable feedback and comments helped me in realizing this project efficiently within the stipulated time period. I would like to thank dr.ing. Peter van der Waerden and prof. Bauke de Vries for their helpful comments and extensive guidance whenever I needed. The collaboration with you all was indeed fruitful in every aspects.

I would like to thank my family, especially my parents because of whom I got this opportunity to study in world renowned university and explore another part of world. Without your love, support and guidance this journey of MSc wouldn't have been possible.

Lastly, I would like to thank my friends, now I can say throughout the world for motivating me whenever I felt stressed and making this journey smooth.

Rohan J. Itkelwar
Eindhoven, July 2017

Summary

The necessity to tackle problems regarding CO2-emission has been identified as an important topic during international climate conferences. This provoked government authorities of various nations to take initiative in this field. European Commission made agreements to achieve 20% energy efficiency by 2020. Also, United States has undertaken a National Action plan which aims to increase investments in cost-effective energy by 2025. However, built environment accounts for a significant share in energy consumption. In Netherlands, the total amount of energy used by buildings is about 35% with share of residential and commercial buildings being almost equal. Also United States has observed similar figures with residential sector consuming 37% energy and commercial sector consuming 35%. With the advent of technology and innovations, the capabilities and possibilities of achieving energy efficiency in buildings has changed tremendously in the recent years. Construction of Zero energy buildings and even Positive energy buildings has been realized to achieve sustainability. However, it is always mistaken that energy efficiency can be achieved by constructing such smart buildings and the concern regarding controlling energy consumption in existing building remains in shadow.

Researchers argues that realizing smart buildings is not effective unless the behavior of the consumers is influenced for energy conservation. Although, the implementation of smart grid by forming a smart meter network has considered existing buildings on large scale, which can provide consumers with their consumption pattern and learning which they can adopt behavior with intention to reduce consumption. However, majority of the residential buildings and small scale energy users are considered in this smart grid. This give rise to the discussion regarding how to motivate employees in office buildings to save energy ? And since existing office buildings accounts for significant part of built environment, they cannot be ignored. Therefore this research aims to find possibilities of reducing energy consumption in an office-type workplace by bringing change in the energy consumption behavior of employees using their energy consumption data. Answer to this question is realized by conducting a research specifically focusing on office buildings, considering various aspects related to potentiality of smart meter to assist development of strategies that can realize pro-environmental behavior of employees in addition to personal characteristics of employees itself.

In order to get insight in possibilities of incorporating strategies with the use energy consumption information that can bring change in pro-environmental behavior and thus the intention to save energy are studied in the literature review. Also potentiality of smart meter to generate energy consumption data that can be processed into meaningful information motivating to save energy is studied. Additionally, researches based on reducing energy consumption in office buildings and residential buildings are studied, since insight in energy reduction possibilities of household buildings can give certain insights helpful for the office environments. However, both setting differs on the grounds of ownership. For household consumers pay their own energy bills whereas in office buildings organization pay bills and thus motivation to save energy among employees is less.

Further literature outlines the importance of environmental and ecological concern in combination with personal characteristics of the consumers that can motivate their intention to save energy. Main factors responsible for bringing out change in energy consumption behavior observed from literature are feedback characteristics i.e. disaggregation of consumption data on various aspects such as

appliance level data, overall data, direct and indirect feedback, group level and individual level etc. Following this another important factors identified are social mechanism factors such as feedback visualization, comparison and gamification. Considering all these factors a conceptual model is drawn which fits to research in office environment.

To execute study respondents were approached through social media and personal contacts. Completed responses form 193 respondents is gathered. These respondents had to choose from 2 different propositions, with each having different levels of attribute effective in determining energy saving. These attributes are categorized as feedback characteristics, social interaction factors and gamification factors. Feedback characteristics consisted of factors related to data disaggregation i.e. feedback type and feedback period; social interaction consisted of factors comparison i.e. comparison with different groups and company's average and information screen i.e. providing feedback on private and public displays; and gamification consisted of factors goal setting i.e. receiving target on energy saving and competition with added feature of receiving reward if target is achieved. The combination of all these attributes has not been implemented in researches in the field of energy reduction in office building.

Descriptive analysis of the gathered data showed that respondents participated in survey are mostly young, bachelor and master and are aware of energy issues. Using Multinomial logit , respondents preferences are measured according to the different levels of six attributes as mentioned above. The attributes with highest preference are from gamification category namely competition followed by goal setting, which shows that receiving reward on achieving target of energy saving has more motivation to save energy than just receiving target. Next important attribute is receiving feedback information on public displays i.e. creating pressure when own data is visible to others, application level feedback and comparison among teams inside office as next important attributes in energy saving with coefficients significant and almost similar. However, the attribute feedback period having levels daily, weekly, monthly, real time did not show any significant result which indicates that combination of other attributes that showed significant results are more motivating than the time period for which these attributes are received. However, estimation of some different models taking into account some different sample groups showed some different results, with goal setting more important that competition for the group of women who has experience of participation in energy saving program. Also for this category comparison with company's average is more important than comparing energy consumption with other team which shows their self-efficacy behavior. Additionally significant difference was found in the attribute feedback period with male having experience of energy saving program indicating negative significance of receiving feedback monthly whereas women with no experience indicated negative significance for daily feedback. According to literature daily feedback has more energy saving potential than monthly, which shows the difference in opinion of respondents experienced and unexperienced in energy saving program. Following this data analysis in random parameter logit model showed that the preferences of respondents are highly heterogeneous meaning they vary with each other which also shows human behavior varies from person to person.

From the observations, it is perceived that the factors that encourages social-interaction such as gamification, public displays, comparison and disaggregation of data on appliance level are significantly influential in energy saving than the time period for which the data is made available.

Therefore, if the management of office organization wants to undertake an energy saving program using the energy consumption data of their employees, they should consider above mentioned factors for maximizing energy saving. And since receiving feedback at different time periods is argued to have potential in energy saving, researching this attribute separately is suggested.

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1 Introduction

1.1 Background

Energy consumption throughout the world is continuously increasing and large amount of almost 20% of the carbon emission is associated with the non-domestic buildings (Climate change: implications for buildings, n.d.). The current energy consumption in Netherlands for Built environment is about 35% and non-domestics buildings account for 50% share of it (RVO, 2015). This sector accounts for 18% of the total carbon emission in United Kingdom (Non-Domestic Buildings TINA, 2012). The figures from U.S. Energy Information indicates the commercial sectors accounts for 35% of total energy consumption which almost equal to their residential sector (37%) (Energy and Environment). These figures gives the insight in the vast amount of energy used in the non-domestic sector. With the continuous increase in energy consumption, assumption says that, electricity will take a large share of total energy consumption in the near future. Increase in the adoption of the plug-in hybrids and electrical vehicles along with the electrification of consumer goods is one of the main reason for this impact (Lampropoulos, 2010). When this argumentation comes out to be true, it will have adverse effect on the demand of electricity.

It is very difficult to forecast the supply and demand of energy in the future energy market, since the renewable sources of energy generation are very less predictable. Hence, to meet the balance in supply and demand and cope up with this trend, a major transition of moving towards sustainable development is necessary. With the advancement in technology and through development and innovations in the built environment, the capabilities to encounter this problem has increased. Moreover various countries are taking strong initiatives to promote energy savings. In Europe, the European commission established an Energy Efficiency Directive which consists of a set of binding measures using which EU can reach the target of saving 20% of primary energy consumption by 2020 (European Commission, n.d.). In the United States, a National Action Plan for Energy Efficiency has been developed with the objective to increase investment in cost-effective energy efficiency by 2025 (National Action Plan for Energy Efficiency Vision for 2025: A Framework for Change, 2008). This shows the awareness to tackle energy issues is increasing with the everyday passing. In addition, now a days people are able to construct zero energy building and even positive energy buildings. Government in Netherlands, has set up a plan called BENG (Bijna Energie Neutrale Gebouwen) buildings, English translation of which is zero or positive energy buildings which states that the newly constructed buildings should meet the requirements to achieve the goals set by the government authority from the end of 2020 in according to the shift towards green environment (National Plan nearly zero-energy buildings, 2012).

However, it is always mistaken that the sustainability can only be achieved by building new energy efficient buildings. And with this belief attention towards making the existing buildings more sustainable mostly remains in the shadow (Agentschap-NL, 2010). For residential and small scale energy users governing authorities within different countries are actively striving to bring change. For these consumers to achieve sustainability in form of energy saving, a major transition of moving towards a decentralized market is observed in the working of energy market. Traditionally, energy is predominantly generated by the large-scale power plants. To break this traditional setting, the European Union is focusing on different energy generation by means of renewable sources. In addition, the energy industry has to adopted “smart grid”, which means it has to move towards a

digitally operated electrical grid. Using this smart gird a network can intelligently integrate the behavior and actions of the consumers in order to efficiently deliver sustainable, economic and secure energy supply. For the implementation of Smart grid, smart meter is attached to every small scale energy user using which the smart grid can read the energy consumption data of the consumers and additionally the feature of these meters enables the users to get insight in their consumption pattern ultimately helping them to reduce energy consumption (Energy, n.d.). However for many non-residential buildings because of the legal obligations and financial difficulties the policies for effective targets are still insufficient. There are some proposals to make the existing building energy efficient on longer terms (Vringer, 2016). But there is immediate requirement to tackle this issue.

For the non-domestic building, the management and the employees in these commercial buildings are lagging for their concern towards energy saving measures. The main reason for this ignorance is due to the lack of enforcement and also partly because for some of them it is not the priority. The potentiality of cost effectiveness by implementing energy saving measures are often unknown and therefore not identified by these organizations. Therefore in order to achieve sustainability by reducing energy consumption, effective measures to create awareness and encourage the users of non-domestic buildings should be realized. Although integrating large non-domestic companies in this smart grid is not undertaken effectively, the management of these organizations on building level can integrate the smart meter infrastructure to bring some positive impact on energy saving measures. Therefore the proposed framework of energy saving using smart meter data can effectively make this happen if the implementation of measures would become compulsory.

1.2 Problem definition

As aforementioned, the demand for electricity is assumed to increase in the near future because of innovations in the high tech market such as automotive, plug-in hybrids and increase in the electrification of consumers good (Lampropoulos, 2010). It is an alarming situation to control this demand in present so as to cope up with the supply in future. The everyday increasing issues of global warming and carbon dioxide emission also is the outcome of the excessive energy consumption. The need to take action to intervene in this field has become very important in order to limit the utilization of energy with the aim of saving it.

In a domestic setting, it is at least to some extent the utilization of energy is relevant to the consumers since they have to end up paying the bills for the amount of energy used. But in case of non-domestic setting, the feeling of how does it matter to me? I am not paying the bills, is always inherited within the attitude of the employees (Lokhorst, 2015). Also the large number of the consumers in the work place typology of buildings makes it difficult to reduce consumption. All this adds up to the fact that the energy consumption in office buildings is not under control and it cannot be neglected. A better intervention is required in order to limit this to a great extent.

This issue of saving in energy consumption has been now one of the most challenging topic worldwide and the respective governments are finding solutions regarding this. Just from the literature as we see, the grid operators started incorporating the energy saving program to save energy for the household level, the management authority in the office setting should also take steps to work on this challenge. It is highlighted in the research that energy efficient buildings often requires considerably more energy in use than originally predicted (Ornetzeder, 2015). It would be interesting

to research the way buildings are currently used in the current times. However, the energy utilized by buildings is not the result of building itself but the outcome of user action i.e. users using various facilities consuming energy within a building (Kolokotsa, 2011). Different users have varied actions and are unpredictable which can led to adverse effect of building's energy efficiency (Janda, 2011). In other words, user behavior is one of the major cause for this. For instance the lights are unnecessarily left on when not needed, not switching off desktop and other devices when not needed etc. This behavior is not often linked to unwillingness since they are enough educated to have knowledge about sustainable behavior, but because of lack of rules, regulations and guidelines they do not find it important to perform the behavior within the office environment. According to Jonkers (2010) guidelines and rules can bring about a bring difference to implement this behavior. With the smart meters installed in the offices, employees can have a detailed timely information of the energy usage. But Installation of actual smart meters without giving the employees' prior knowledge about their consumption behavior and motivating them to save energy will most likely does not have large impact on their behavioral change.

1.3 Research framework

The main objective of the research is to study the possibilities to minimize the energy consumption in office environment by influencing the behavior of employees. As aforementioned, smart meters has the ability to provide detailed information of the consumption analyzing which employees can get the insight in their consumption pattern. Therefore the potentiality of smart meters to integrate with behavioral change factors would be studied in this research. Since the issue of energy conservation is a worldwide topic, therefore this study is not limited to any region or country. Although it is global study, the climatic differences of various regions are not considered since the study is related to changing behavior intention of the employees in office buildings using smart meter data and not the climatic or thermal comfort. Therefore, whatever information about the office equipment used in this research would be mainly regarding the commonly used equipment worldwide. Additionally, as there is no organization involved in the study that can provide the smart meter data of the energy consumption of their employees, the information used would be hypothetical but close to real life and would be in accordance to the literature.

1.4 Research questions

How can feedback on energy consumption data change the energy consumption behavior of employees in an office-type workplace?

The research sub-questions relevant for the thesis are:

1. How does the energy consumption behavior of employees in office type buildings look like ?
2. How can energy consumption data help organization's management to change the energy consumption behavior of their employees?
3. Which variables can be implemented in the energy saving applications so as to provide meaningful feedback to the employees motivating them to save energy ?
4. How can these variables useful for energy saving be shown to employees using feedback displays to enable them get insight in their consumption data and drive them to save energy?

1.5 Research design and reading guide

The research consists of different phases and the data would be collected with relevant methods for these phases. These phases are divided into different chapters in this report and the explanation of these chapters is outlined in the following paragraphs. At the end of section a research model (figure 1) is presented based on these phases/chapters.

Chapter 1

In the beginning of study, the background, purpose of study, problem definition, research framework and research questions are illustrated as aforementioned in the previous sections. Following this in current section, research design, reading guide and research model is discussed in brief.

Chapter 2

Firstly of all, the very first step is to execute literature review in order to understand the functioning and potentiality of the smart meters in practice. In addition, some already implied smart meter projects would be studied.

As this study focuses on reducing energy consumption by the means of behavioral change, an extensive study on pro-environmental behavior and curtailment behavior would be performed in order to get insights in what factors can determine change in the behavior of the employees that will drive their intention to save energy.

Afterwards, the factors that are identified from the behavioral change framework would be studied in detail in order to understand its applicability in this research. In addition, some previously executed work based on the applicability of the behavioral change factors in integration with smart meters will be studied. This would give the clear understanding as to how these behavioral change factors can be incorporated in this study with the focus on data generated by smart meters.

Later, as this study is focused on reducing energy in office buildings, therefore the possibilities to divide the energy consumption in groups or on individual level and its potentiality in decision making to save energy would be studied. Additionally, how this data can be disaggregated meaningfully and made visible to the employees which can drive their intention to save energy will be reviewed.

Afterwards, the impact of socio-demographic characteristics and the behavior, attitude and psychology of the employees for the energy and environmental concern would be studied and hypothesis on the combination of socio-demographics characteristics and energy concern would be outlined which can give the insight in their behavioral intention to save energy.

Lastly, after studying all the above mentioned aspects necessary for the study, a conceptual model illustrating the composition of concept intended to study in this research will be outlined which will be further considered in executing the study.

Chapter 3

Third chapter outlines the approaches used for answering the research questions presented in section 1.4. As this study is related to energy saving, descriptive study approach based on socio-demographic characteristics and factors focusing on behavior, attitude and psychology to save energy determined by literature review will be outlined. This will give the insight in formulating the questions that can further highlight behavioral intention of people working in office environment to

save energy. Subsequently, help in validating the hypotheses outlined in literature review based on combination of socio-demographic characteristics and exposure to energy concern. Along with this, the choice experiment will be set up depending upon all the findings form the literature. Firstly the guidelines of developing the choice experiment would be reviewed, later the choice experiment on those guidelines would be constructed. As this study relates to changing behavior with the insight in their consumption, the variables presented in the choice set would be reconstructed graphically to make respondents understand the hypothetical situation.

Later, the detailed questionnaire constructed using both descriptive study approach and choice experiment that will be circulated globally to the employees working in office environment so as to collect information about their ecological concern and their preferences in determining energy saving from various options displayed in the choice experiment will be illustrated. Additionally, various methods to analyze the data thus gathered would be outlined.

Chapter 4

In fourth phase, firstly descriptive analysis would be executed that will provide the information about the socio-demographic characteristics and the behavior, attitude and psychology of respondents related to energy and environmental concern. Additionally, hypotheses in combination of these socio-demographic characteristics and energy concern realized through literature review would be validated by executing hypothesis test. The collected data would be then analyzed using Multinomial Logit Analysis from the NLogit software. This will help in determining which factors proved to be important in determining their behavioral intention to save energy. Later, MNL analysis of additional model that can help to draw conclusion for different group of respondents and realize the possible differences regarding their preferences for influential factors to save energy. Afterwards, the data would be analyzed in Random parameter logit model to see the heterogeneity/homogeneity of the respondents choices. And finally the best option that can influence the behavioral intention of employees in office buildings would be illustrated.

Chapter 5

Fifth phase will start with focus on writing down conclusions based on the outcome of the analysis along with answering the research questions. In additional, some practical implications necessary for the study and its relevance with the theory/science would be expressed. Also discussion regarding the weakness of the research and the possible improvements would be discussed. And finally recommendations for the future research and some suggestions to the stakeholders working in the related field would be addressed.

The complete flow of the research design can be found in figure 1 research model.

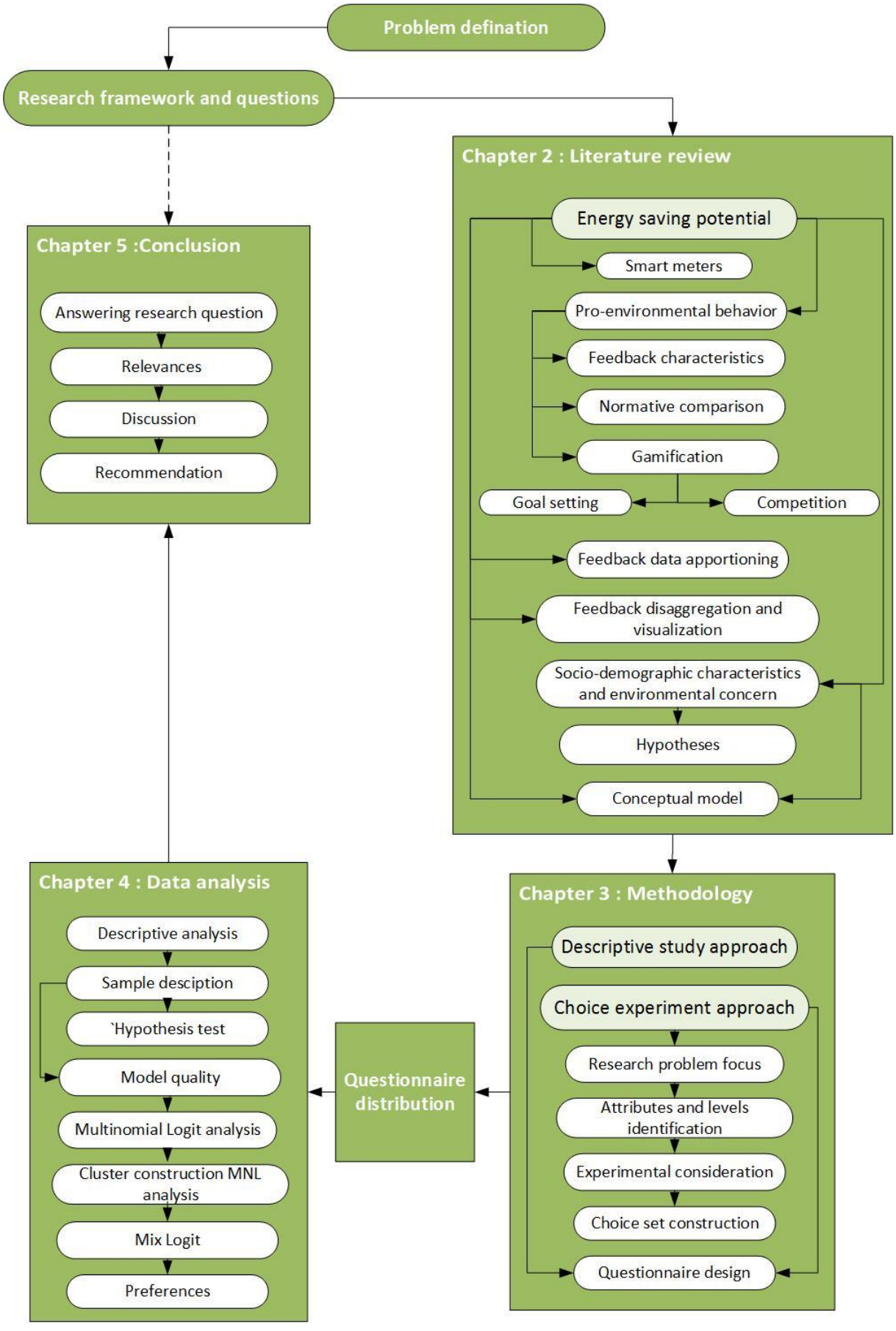


Figure 1 Research model

2 Literature review

2.1 Introduction

As seen in the previous chapter, the energy demand worldwide is increasing rapidly causing a tremendous carbon emission with 20% of total being emitted by non-residential sector. In Europe itself the rise in demand of energy for non-domestic sector account to 30% between the years 1990 and 2009. Similarly, the figures of this energy consumption is even worse for other region. With this increase in demand of energy and emission of carbon, majority of the regions are undergoing energy conservation initiative for the welfare of both society and environment as it can be seen from EU's 2020 target to reduce emission by 20% and US's National Action Plan to increase investment in cost-effective energy efficient infrastructure by 2025. Therefore, with the requirement to conserve energy and thus enhance the environment quality initiatives such as sustainable development with the focus on building Zero or Positive energy buildings has been undertaken with everyday advancement in technology and knowledge.

It is appreciable that various organizations are able to build energy neutral buildings. However the main question lies in does these so called energy neutral buildings really act smartly to tackle this issue? Because, reduction in energy use is not only realized by applying new technologies to construct a building, but it lies in the mind set, behavioral attitude of the consumer using it. In other words, if the occupant of the building is not informed and assisted to reduce his/her energy use, even the best design of building with energy neutral installations will fail to support for this cause and even its performance can be worse than conventional buildings (Lenoir, 2011). Therefore, in order to bring the change in energy consumption with the motive of reduction, along with applying new energy efficient technologies in buildings, behavioral attitude of the people should also be changed.

With this intention of bringing behavioral change in the consumer's mind set, the shift from conventional energy market to decentralized market known as smart grid is observed. The mechanism of which lies in creating a network by providing smart meters that can give consumers insight in their energy use and also help the energy providers to understand the consumption pattern of the customers and bring in change in their behavior by applying strategies such as price differentiation. However, for this movement the targeted customers are the small scale energy users like residential buildings and small scale business. But the discussion arises how to deal with the energy reduction in large scale and corporate offices?

Office environment and household settings vary however on a number of characteristics, creating very different contexts for behavior change interventions. For most of the employees the cost of energy utilized in workplaces for various purposes are of very less relevance to them since there are no such individual financial incentives. Since employees in an organization are more numerous than that of the normal household members, the incentive to save energy is not so readily possible and it is thus less efficient. Also the information regarding energy use is corresponded on a group level causing reduction in employees' sense of individual responsibility (Lokhorst, 2015). All these constraints increase the challenge to reduce the energy usage in an office environment than that of household and interventions should be carried out taking these facts into account.

To a greater extent, researches have been focused on residential or household energy use. Few of them have precisely concentrated on changing energy use in private or public organizations. Matthies

and Hansmeier (2008) discuss an intervention at a German university, which combined information, commitment and prompts and the outcome of this intervention was successful. A significant behavioral change was observed among the participants and the energy used for heating reduced by 6% during the experimental time span. Carrico and Riemer (2011) Assessing the impact of peer education and group-level feedback in a case of university employees and the outcome showed that both resulted in significant energy reductions. Examination if various information strategies such as different types of feedback, brochures were effective in endorsing energy saving in an office building. Positive results were reported at the end of intervention, with partial behavior maintenance after a year. Hung-Ming Chen and team (2012) illustrates a study in which researchers from the university receives the energy usage feedback on their computer screen in the form of digital pet. This intervention resulted in successfully attaining the conservation objectives. Closely observing the approach of these interventions, it is clear that the potentiality of reducing energy consumption lies in change in behavioral intention of the consumers.

Realizing the potential of smart meters as it can provide detailed information to the consumers and from above interventions the possibility of energy reduction in office buildings through behavioral change is clearly visible. Although, corporate offices are not considered in the smart grid, but if the management of the offices understands the potential of smart meter and integrate it at office level with already researched strategies or even few new idea that comes along with smart meters that can determine change in the intention to save energy can give rise to an optimized solution to this energy conservation issue.

To realize the potentiality of this integration of smart meters and behavioral change strategies, this literature study aims to create an overview of how various smart meter applications and the behavioral change strategies can be combine to bring change in human behavioral and influence them to reduce energy consumption in office buildings. In this field of study, already various researchers contributed to bringing out change in consumers behavior that can ultimately result into energy reduction. However, many of them focuses on the domestic environment and very few on the office typology. Nevertheless, the learning from those applied on household levels can also assist to form an effective framework.

2.1 Smart meters

Figure 2 Smart meter

The invention of smart meters can be traced down from 1977, when Ted Paraskevakos an American technology developer launched Metretek, Inc. which developed and produced the first fully automated remote meter reading and load management system which was commercially available in the market. As this system was developed in the pre-internet time, Metretek utilized the IBM series 1 mini computer. For this innovation Metretek and Paraskevakos was also felicitated with various patents (Smart meters, n.d.). Later with the advancement in information technology, this approach lead to the development of smart meters. Over the period of time advancement in smart meters and the emergence of advanced metering systems has increased its used for various purposes in the field of energy. Advanced metering infrastructure are the system that makes smart meters functional by measuring, collecting and analyzing energy usages and communicating them with the metering devices such as electric meters, gas meters, water meters and heat meters. These systems comprises of hardware, software, communications, consumer energy displays and controllers, customer associated systems, meter data management software and supplier business systems (Smart meters, n.d.).

Attractiveness of its feature to analyze the user consumption, smart meters gained popularity in the field of energy saving. To narrow down its usability in the electric energy sector, smart electric meters are basically the electric meters that maintains the energy consumption record in a more detailed manner. Since these meters are integrated with a network using information technology enabled interface, they provide system operators one way or two way electronic communications with residential and commercial consumers as well as the power generators. Moreover, these meters also gives the consumers the information about their energy consumption pattern, which assists them to lower down their energy usage (Vadda, 2013).

2.1.1 Functioning and usability of smart meters

Considering the superiority of advanced metering infrastructure as it provides bi-directional communication, it implies the deployment of heterogeneous infrastructure that consists of smart metering devices, communication networks, data gathering and processing and associated management and installation duties (Uribe-Pérez, 2016). The smart metering system is based upon the four important functions:

- Smart meter device (smart meter)
- Data gathering device (Data concentrator)
- Communication system essential for data flow
- Centralized management and control system (control center)

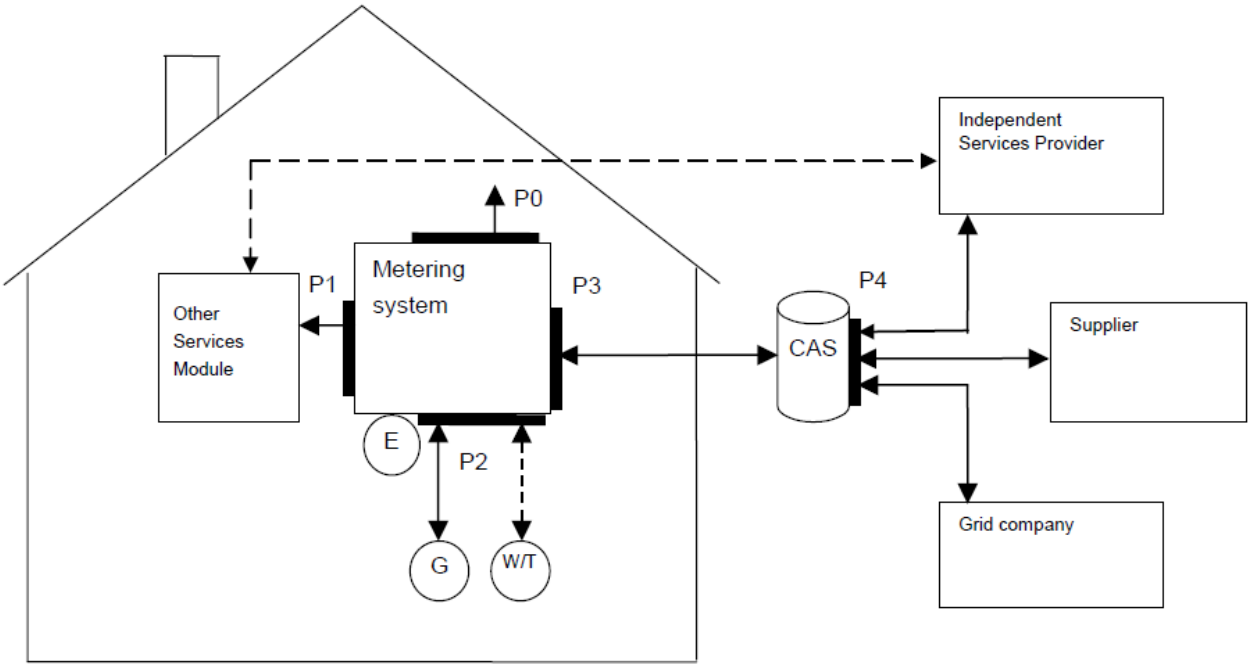


Figure 3 Smart meter design (KEMA Nederland B. V., 2010)

As aforementioned, smart metering systems consists of heterogeneous infrastructure that consists of different requirement and features as they are highly dependent on intended use. Additionally the communication between the above mentioned functions is executed using different ports used in smart metering system. To understand its usability the Dutch Smart Metering Infrastructure is studied (KEMA Nederland B. V., 2010). Smart metering system comprises of the four ports. The first port P1 is used to connect different types of devices to the smart meters. Using this port the office area network can be formed by connecting various devices and appliances used by the employees in the office. This port also enables the consumers to read the data. By adding additional device that can monitor and control the data by displaying the application showing the consumption to the consumers and that can stimulate energy saving. These ports are only to read data from the meters. Different geographical locations has different source or combination of sources to generate energy such as gas. In order to calibrate these different sources to the smart meter system the meters of these sources are attached to system using port P2. The third port P3 is the communication server between the smart meter system and control center (Central Access Server for Dutch metering system). This control center receives and stores the data for processing purpose. Port P4 is attached to the control center using which authorized parties can get access to the energy consumption data. Additionally, the authorized parties such as energy providers or energy application developers can skip the process of receiving data through control center and can directly access the consumers by providing an application to their consumers which they can connect to port P1. They can access the data every 10 seconds using internet connection. For the non-domestic companies, if they are not the part of smart grid, the can still make use of port P1 to access and deliver the information in the form of energy saving applications.

2.1.2 Smart meter potentiality in energy conservation through behavioral change

Installation of actual smart meters without giving the consumers' prior knowledge about their consumption behavior and motivating them to save energy will most likely does not have large

impact on consumer's behavioral change. Other market players for example business communities have to deliver convenience for the consumers to save energy. Since the amount of energy consumed is indirectly influenced by them. For instance, the amount of energy saved depends upon the type of feedback provided to consumers on energy consumption (Geerts A. , 2013). Therefore, the market players who would cater the consumers with these additional products would indirectly succeed in saving energy.

Netbeheer Nederland states that different players in the energy market have different advantages of smart meters and smart grid (NETBEHEER NEDERLAND, 2012). Theoretically smart meters can measure the electricity consumption every 10 seconds. This brings in the possibility for consumers to get insight in their near real time consumption. Smart meters can enable consumers to access accurate, up-to-date information on their energy usage which will help them to have larger degree of understanding and control in monitoring and reducing their energy consumption and costs. It is expected that the consumers will get more concerned about their energy consumption and hence can more efficiently contribute in energy saving (Working Smarter: Realising the potential of smart meters in business, 2014). Also the market players or energy suppliers will be benefited from the accurate information from smart meter, allowing them to improve the standard of service they offer and develop new services and applications that can give consumers insight in their consumption behavior. Many researchers argues that energy consumption behavior of the consumers can be transformed with the help of these insights and feedback on energy consumption (Wokje Abrahamse L. S., 2011; Dario Bonino, 2012; Geerts, 2013).

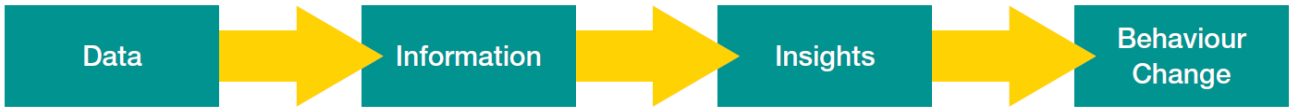


Figure 4 Behavior change intervention using smart meter data

A research carried out by Bradley (2014) in a workplace type environment using smart metering technology uses the smart meter data to analyses the energy usage before and after the intervention by incorporating the social norms in the study. However, this study focuses more on role of social norms and gathers data using smart meter, it also leaves suggestion of incorporating smart metering technology to energy saving behavior phenomenon (Bradley P. L., 2014).

2.1.3 Smart meters in practice

With the intention of saving energy and contributing in the reduction of energy use, governing authorities and energy providers worldwide started smart meter implication and its roll out. The primary objective of grid operators and the governing authorities is to settle down the rise in energy demand and save energy which is possible with the help of smart meters. This can contribute in balancing the supply and demand and thus accomplishing the goal. It is very important to balance load while working in the decentralized energy markets, and this is only possible with the help of smart meters.

Europe

Energy research center of the Netherlands states that between 2009 and 2014, smart metering projects were deployed on a large scale. And they aim at implementing smart meters in 80% of the households until 2020 (Elburg, 2014). The government agreed upon the proposal for a new market

model for consumers and small businesses (Elburg, 2014)`. Within this initiative, the Parliament set forward a plan to implement a system named 'Dutch Advantaged Metering Infrastructure' that can smartly integrate the actions and behavior of all the connected users with the goal of efficiently delivering economic, sustainable and secure electricity. With this system in function, electricity grids can balance and accommodate the transmission load in much better way so as to fulfill the needs. World largest deployment of smart meter was undertaken by the Enel, the dominant energy provider on Italy with more than 30 million customers. Between 2000 and 2005, they deployed fully electronic and advance smart meters to its complete customer base. The system also provides a wide range of advanced features such flat rate to multi tariff, ability to remotely turn power on/off to customers etc.

United Kingdom realized its first step in 2007 with the start of program "Energy demand Research Program"(EDRP) (Uribe-Pérez, 2016). Smart meter rollout in United Kingdom is also considered as the largest program ever undertaken which consists of consultation and visits to 30 million homes and 2 million small non-domestic profiles of 3 and 4 (typically specified as small and medium sizes companies comprising 250 or fewer employees) (Working Smarter: Realising the potential of smart meters in business, 2014). The smart meter would be installed by the energy provider between 2015 – 2020. Through EDRP installations of 58,000 smart meters illustrating the combination of smart meter and in house display contributed to a real difference in level of energy consumption by people. In 2011 the UK government also announced mandatory smart meter roll out comprising installations of 53 million smart meters in 30 million homes and businesses between year 2014-2019.

America

United states "American Reinvestment and Recovery Act" (ARRA) has undertaken the rollout of smart meters. According to the report from Institute for Electric Innovation, in 2014 total of 50.1 million smart meters were installed with the penetration rate of 36.3% and the deployment of smart meters is still increasing. Majority of these smart meter installations are for the residential use (43% homes have smart meters) since may commercial organizations has installed them quite earlier to monitor electric usage more accurately (Institute for Electric Innovation, 2014).

China

As a part of National Plan, electricity companies in China has undertaken extensive smart meter roll out in accordance to bring improvisation in national electricity infrastructure and realize shift towards green energy supply. With this plan in action, China has become the largest market in the world for the smart meters. The deployment of smart meters is expected to grow from more than 139 million units in 2012 to 377 million units by 2020 by attaining the market penetration of 74%. China's only state owned company Smart Grid Corporation of China (SGCC) is world's largest electric utility company in the world that provides electricity to 88% of the China (Uribe-Pérez, 2016).

Australia

In Australia smart grid and smart meter deployment has been initiated by governmental programs with the focus on energy security, data management and energy efficiency. As a result of major energy shortage problems encountered by the country during 2006-2007, an attempt to improve energy supply system has been realized. In fact, as a comeback to these energy problems, a government committed body deploying smart meter roll out was initiated as apart of National Smart

metering Program. The state of Victoria was the first state chosen through cost benefit examination and a compulsory roll out program started in 2009 and finished in 2013 leaving 2.8 million smart meters in action (The Global Smart Grid Federation Report, 2012).

2.1.4 Conclusion

Literature in this section gives the complete overview of the working of smart meter with highlighting the smart meter infrastructure undertaken by the Dutch government. Understanding this infrastructure, the possibility of integrating office buildings energy consumption into smart grid and also on individual level is studied. Later, the potential of smart meter in bringing out change in behavioral intention to save energy using the energy consumption data from smart meter is realized. And as observed, smart meter has an extensive potential in bring out change in the consumption pattern of the employees in office buildings. The proper collaboration of the influential behavioral characteristics along with the optimized feedback characteristics can make this possible. Also insights in the current utilization of smart meters and smart grid deployment initiated by various countries in the world gives a motivation to tackle the energy conservation issue as the figures shows that a large scale directive has been undertaken by these countries which shows the potentiality in energy saving lies extensively in smart meters.

2.2 Human behavior related to energy conservation

Energy related behaviors can be distinguished in two categories, namely curtailment and increased efficiency (Gardner, Environmental problems and human behavior, 2015). Curtailment behavior are the actions that needs to be carried out in a continual time period in order to be effective, e.g., switching off electrical appliances and lights. In contrast efficiency behavior attributes to a one time decision making such as installing solar panels. In office typology buildings, the higher (management) authority is likely to take decisions regarding increased efficiency. Curtailment behaviors on the other hand are possible for all personnel and afford substantial energy savings.

Curtailment behavior can be connected with the pro-environmental behavior which also has much to offer our understandings about the energy used in workplace. Just like the curtailments behavior deals with the fact of reducing or restricting something, pro-environmental behaviors are the behaviors that intentionally seek to reduce the negative impacts of a person's activities on the natural and built world such as reducing one's use of energy in this case. Disciplines including psychology and sociology in particular have sought to understand what drives limits and sustains pro-environmental behavior (Staddona, 2016). Various theories and models has been proposed, intervened and developed to carry out empirical investigations around this domain. Research in 1970s used assumptions based on information deficit model, suggesting the possible ways to translate knowledge of how to reduce the environmental impacts into environmental behavior. This logical approach must be true in some instances, but it is observed that people do not act in accordance with their values or attitudes, giving rise to so-called attitudinal behavior or value action gap. This gap has been characterized by circumstantial influences, differences between individuals, temporal inconsistency (changing people attitude over time) and also the approaches used in analyzing attitudes against behavior (Staddona, 2016). Theory of Planned Behavior(TBP) proposed by Ajzen has significantly influenced researches into this gap (Ajzen, 1991). It suggests that behaviors are driven by intentions which themselves are driven by a combination of attitudes, subjective norms and perceived behavioral control. Another such exceptionally influential model to analyze pro-environmental behavior is Value-Belief-Norm (VBN) mode by Stern (1999) which argues that values are nothing but the individual's beliefs and which are in turn model intentions to act through norms.

To review pro-environmental behavior and energy use behavior change in the direction of workplaces, studies found that the pro-environmental behavior rely on both individuals determinants like attitude etc. and organization specific influences like managements. It also highlights the poor understandings of the interaction between individual and organizational factors (Staddona, 2016). It advices that the interventions to promote pro-environmental behavior in workplaces should not only be addressed towards the physical facilitation, but also be focused on the tailored effective ideas and the active participation of middle management. A meta-analysis of the investigations to endorse pro-environmental behaviors in the workplace finds that cognitive dissonance (where differences between actions and pre-existing attitudes or values are highlighted), goalsetting, providing role models (social modelling), and prompts which comprises of giving instructions, providing feedback, offering rewards, seeking employee commitment (Osbaldiston, 2012).

Regarding energy use behaviors in the workplaces, researchers has considered retail, industrial, manufacturing environment as well as office office-type environment. They concluded that the

important psychological factors for saving energy are more broadly similar to those within pro-environmental behavior and they include moral norms, personal responsibility, antecedents' beliefs and pro-environmental attitudes. Furthermore it also mentions the importance of employee engagement during all the steps of energy saving programs through participatory interventions which assists the progress continual employee involvement (Staddona, 2016). To execute this the office management and organizational decision making plays an important role in creating opportunities to reduce energy.

One important instrument to intervene the pro-environmental behavior is Behavioral change wheel (BCW). Staddona (2016) states that although it is a systematic review of 19 previous framework on behavioral change interventions particularly from the health related researches, its roots are attached to the theories related to pro-environmental behavior. The BCW explicitly describes the three main classifications namely source of behavior, intervention functions and policy functions. The intervention functions (education, persuasion, incentivisation (giving incentives), coercion, training, restrictions, environmental restructuring, modelling and enablement) described in the wheel has been majorly used by researchers to intervene into the energy saving behavior (Staddona, 2016). An article in journal energy research and social science by Staddona (2016) also provides a synthesis and analysis of 22 studies around the world that identifies energy saving interventions in using the BCW and finds out the most successful behavior change interventions in an office-type workplace. Their findings say that the most successful interventions are those that create social and physical opportunities for employees to save energy. They further adds that energy savings in the workplace depend not only on the individual and collective actions of employees, but importantly also on the attitudes and engagement of management, on wider organizational change, and on investment in energy efficient technology (Staddona, 2016).

2.3 Using Theory of planned behavior to understand behavioral factors of energy saving

Icek Ajzen designed the theory of planned behavior (TPB) in 1985 to help explain human (adoption decision) behavior in specific context (Ndah, 2010). It predicts the deliberate behavior, since behavior can be deliberate and planned. We use TBP to model questions in survey to get a complete overview on the behavior our respondents perform in everyday life. The theory of planned behavior is an extension of the theory of reasoned action and it defines the link between beliefs and behavior. The theory of reasoned actions is an outcome of various theories of attitude such as learning theories (Truong, 2009).

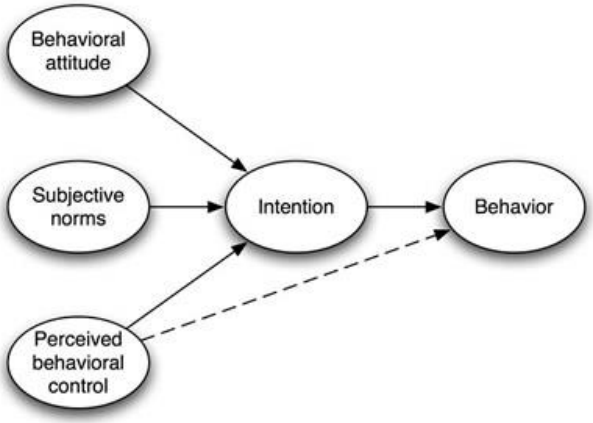


Figure 5 The theory of planned behavior, Ajzen (1985)

Theory assumes human activity is governed by three kinds of considerations namely 'Behavioral Beliefs', 'Normative Beliefs', and Control Beliefs' (Geerts A. , 2013). Theory states that the people's behavior is influenced by the behavioral attitude an individual has towards the behavior. Behavioral belief is the person's approach to perform the behavior considering the target behavior. i.e. when

the target behavior is evaluated as positive, person's intention to perform the behavior will be higher and they will be more inclined to do so (Pavlou, 2006). Furthermore the normative beliefs deals with the person's perception of social normative pressures. This perception is influenced by the opinion of significant or important people to them such as parents, spouse, friends, colleagues etc. which helps them to take decision whether to perform or no to perform the behavior. Lastly, control beliefs determine the existence of factors that are conceptually related to self-efficacy. In other words, it deals with the individual's beliefs about the existence of factors that may facilitate or hamper performance of the behavior-adoption (Theory of Planned Behavior, n.d.). It is influenced by the easement by which a person can execute the behavior or his/her thought of executing the behavior (Geerts A. , 2013).

In the model behavior intention recognizes an indication of an individual's readiness to perform a given behavior. It is driven by the factors: attitude towards behavior, subjective norms, and perceived behavioral control, with each predictor weighted in relation to the behavior and population of interest (Geerts A. , 2013). Defining behavior, it is nothing but the actual response a person performs in a given situation. So, the mechanism of TPB model can be expressed as, the more positive the attitude towards a behavior and subjective norm, and the greater the perceived behavioral control, the stronger will be the intention to perform the behavior and the higher will be the change in behavior to perform.

2.3.1 The theory of planned behavior in environmental research

The theory of planned behavior has not been used widely in the researches related to the energy conservation literature (Laudenslager, 1998). Yet, some of the literature focuses on the applications of TPB model in order to understand the behavior of consumer in the environmental protective research domain. Since, environmental researches also considers CO2 reduction, it is interesting to have insight in the papers considering the research questions.

The conclusions from the environment research shows that the actual behavior are the output of the behavioral intention and they can be strongly related to each other (Laudenslager, 1998). This indicates that the use of TPB in our research would not have any negative impact on the reliability of the research. In addition, the literature states that the variance in the environmental behaviors cannot always have association with the environmental attitude. (Scott, 1994) Findings from researches suggests that the factors those are closely related with theory of planned behavior are important to understand the people's behavioral intention regarding environmental programs. This suggests that the variables perceived behavioral control and subjective norm which are independent in nature are useful and important considering the environmental research.

The relevance of the variable behavioral attitude in the environmental research can be traced down from the researches on recycling behavior. Researches on recycling behaviors concludes that the opinion of the peers is very important while making recycling decisions i.e. consumers' beliefs regarding their peers' attitude towards behavior predicted their own attitude towards recycling (Bratt, 1999). This effect on recycling decisions has direct relation with the behavioral attitude, which ultimately defines the actual behavior that will be performed in real life. Bratt's study also explains the relevance of the component perceived behavioral control from TPB in environmental research. He argues that personal control, conservation behavior and recycling behavior have a strong relationship in between. Out of the literature found in the domain of energy conservation, energy feedback etc., most of them were conducted as real life pilots. The outcome of such interventions

results in a higher construct validity since the realism of context is clear and moreover people perform activities as a part of their normal life routine. In accordance with the scope and goal outlined in this research we prefer not to conduct a pilot but to use the theory of planned behavior instead.

2.4 Feedback in energy conservation

In order to research contribution of smart meter data in changing behavioral intention to save energy, it is very get insights from the consumers point of view. Feedback on energy consumption is nothing but making the consumers informed about their energy use which can realize change in their behavior to save energy. Consumers gain full insight in their energy consumption through the consumption information produced by smart meters. Advancement in IT has led to discovery of applications such as Plugwise (Plugwise, n.d.) which provides the consumers real time information of their usages per device. And such developments give new innovation angles to the energy saving discussion. The next paragraph discusses the current literature that relates energy saving to feedback on energy consumption.

Energy can be saved by giving the consumers information about their energy consumption (Bonino, 2012; Gerwen, 2010). With this approach smart meter data can led to change in consumption behavior, different behavioral intentions, energy conservation and more efficient use of energy infrastructure. (Bonino, 2012) Only the introduction of smart meter will not help to attain the goal. The consumers interaction with the smart meter infrastructure with regards to its use and acceptance can determine the energy saving and CO2 reduction. The European directive states the basic principle of more and improved feedback on energy consumption using smart meter infrastructure which will result in the behavior to save energy (Parliamnet, 2008).

Feedback programs enables consumers to have detailed overview of their consumption. The usefulness of such programs in the form of tools that make modern energy resources like electricity more evident to consumers and enables them to actively manage their energy consumption. These energy programs can be customized and designed so as to obtain the end result of increasing the consumer's informedness. Energy saving literature argues that providing feedback through smart meter data can led to improved energy consumption behavior with regards to energy saving and load shifting (Bonino, 2012; Gerwen, 2010).

According to Linda and Abrahamse (2007), updating consumers with feedback on their energy saving may further encourage them to reduce more energy, since they would feel that their self-sufficiency has increased. It is very important to inform, engage, empower and motivate consumers by combining it with the relevant useful technology when designing energy saving programs (Abrahamse W. S., 2007). Two-sided approach is required in order to achieve maximum saving through feedback. In other words, not only giving consumers insight into the consumption data generated by smart meter is useful, but also actively providing them feedback on detailed level is argued to have even more impact on energy saving (Ehrhardt-Martinez, 2010).

2.4.1 Feedback characteristics

A comparison paper published in 2010 showcases a systematic assessment of information collected from 57 primary studies in the domain of energy saving and energy feedback was outlined (Ehrhardt-Martinez, 2010). These studies researched different approaches on energy usage feedback. The

conclusion from paper states that feedback acts as an important factor when enabling consumers to manage their energy consumption behavior. This paper has a particular focus on energy saving using feedback in household settings, it also concludes that the potential energy saving in domestic settings can be realized from 4 to 12% depending upon the type of feedback provided (Ehrhardt-Martinez, 2010). This paper is considered in literature review since the insights presented in the paper regarding energy saving through feedback can be also be useful from non-domestic point of view. Also it is mentioned in the paper that in order to make consumers believe their capability of making a difference and their motivation to perform the action, the most important is the way in which the feedback is provided to them and the extent to which they understand the information. This paper also emphases on the two-sided approach to change energy consumption behavior discussed earlier. Yet, there is still disagreement about the energy saving programs that can highly bring change in the consumption behavior. And this thesis will contribute to this issue of disagreement. The comparison study highlights that energy savings can vary depending upon the feedback strategies. Ehrhardt-Martinez (2010) argues that feedback provided daily or weekly is less effective than real-time feedback and feedback on device level. Figure 6 shows different types of feedback.

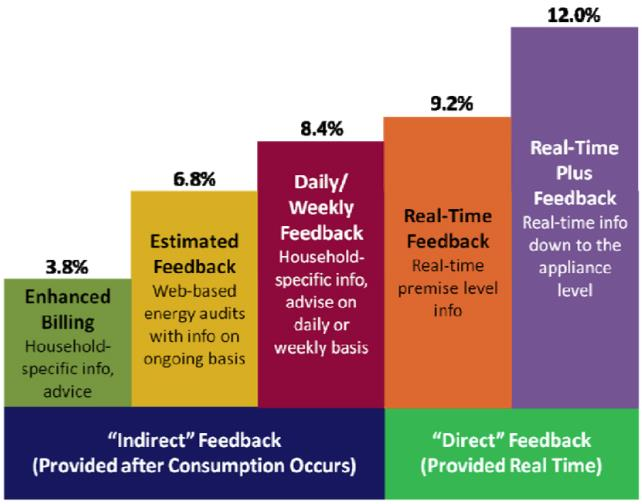


Figure 6 Type of feedback and energy savings. Adapted from (Ehrhardt-Martinez, 2010)

Enhanced billing is the information about consumer's energy usage provided on a monthly, quarterly or yearly bill. For instance this could be an overview of the total consumption per day of the previous month. Using enhanced billing consumers can see for ex. For which days of the month their consumption level was above average. Enhanced billing is argued to achieve 3.8% energy saving. Estimated feedback is an approach where consumer provides information about a household in domestic setting about a households energy saving online. Considering its relevance in our research, it can also be the head member of every team in an office type setting. This approach provides an online platform where questions related to their energy usage would be answered by consumers and afterwards feedback and energy saving tips would be given. 6.8% energy saving can be achieved on an average using estimated feedback. In daily/weekly feedback consumers gets insight in the amount of their energy use on daily or weekly basis. This type of feedback can realize energy saving of about 8.4% on an average. All of these three feedbacks are considered as indirect way of giving feedback i.e. feedback is given after the consumption occurs. Another way of giving feedback is direct feedback and it is argued that direct feedback leads to more energy saving. In real time feedback consumer gets the information about their energy usage in real time i.e. the moment when actual consumption is occurring (Ehrhardt-Martinez, 2010). And it is said to achieve 9.2% energy saving. The real time information can be accessed by the consumers using the screens such as Toons from Eneco (Eneco, n.d.). Additionally, they can also view the energy use of pervious day, week of month etc. Martinez (2010) further characterize the real time feedback down to the appliance level. The comparison study

she carried out, concludes that the such type of feedback can ensure 12% energy saving. So, the mechanism of this approach on feedback works on showing the consumers the energy usage of each device they have in their household. We can link this to the devices used by each group in an office setting where the consumers can see energy consumption of each device in real time.

2.4.2 Feedback and learning

Literature exhibits that there is relation between feedback on energy consumption and learning theory. Some researchers in their studies related to feedback and learning highlights feedback as a part of learning process, where people are termed as information processors who dynamically make sense of their surrounding world (Ellis, 1978). Some researchers specifically intervened into energy feedback and feedback with the energy consumption feedback available through smart meters (Gronhoj, 2011; Darby, 2006). Darby (2006) in his research concluded that direct feedback can be related to learning by paying or looking and indirect feedback can have relation to learning process by reading and reflecting.

The objective of energy consumption feedback and learning is that feedback contributes to construct 'tacit knowledge'. The literature argues that energy consumption feedback enables consumers to get insight in information about their energy usage and their performance. This helps the consumers to understand what has actually happened by interpreting the feedback. It is argued that repeatedly going through this process helps consumers to learn about their energy use as it becomes tacit knowledge. In figure 7, a model developing tacit knowledge through feedback is shown. The model argues that, saving energy through feedback involves consumers in some learning phases. Van Houwelingen and van Raaij (1989) argue that energy feedback has three functions in regard to learning. Firstly, feedback has a function of learning. From feedback consumers learns the connection between their behavior related to energy usage and the amount of energy they use. Secondly, they have to make habit of this information i.e. consumers put forward the information available into regular practice and this may develop a change in their behavior. And lastly, when consumers develop new habits, they tend to change their attitude in accordance with this new behavior. This complete process is called as internalization of behavior and can be related to tacit knowledge.

Learning styles put forward by Kolb (1974) are in line with this. He argues that a consumer has to go through a learning process in order to save energy by feedback on their energy consumption. Since the ability of every human to learn is different from that of others, feedback must be provided to consumer in a way that is in accordance with the learning style of specific consumer and he/she feels comfortable with (Gerwen, 2010). Figure 7 shows a learning cycle that has four different learning styles. Consumers normally go through all these styles when learning (Kolb, 1974).

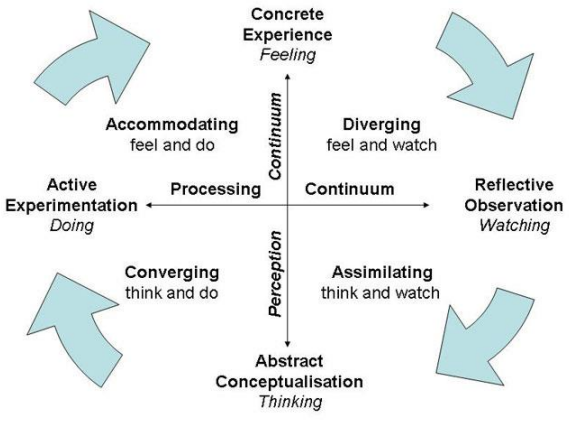


Figure 7 Learning styles of Kolb (1974)

2.5 Comparison in energy saving

A subject researched in relation to energy savings is based on Comparison between own historic consumption or bench marking. Comparison between consumer's own consumption to that of previous periods is historic comparison. In addition, in the energy saving discussion the application of social norms have also been researched. Theory and empirical evidence in relation to norm emergence within organizations states that there are a number of processes that lead to the development of social norms and changes in behavior, namely norm emergence, norm diffusion and translation into behavior (Bradley P. M., 2014). Of these norm diffusion involves the spread of social norms. The emergence process and the diffusion processes includes social construction and social comparison. In the third process, individuals compare themselves with what others do and how they respond to a given situation. Social construction is the theory that norms, beliefs and attitudes are constructed through a process of social interaction (Brooklyndhurst, 2009). The social comparison and social construction process are informed from other referent individuals. This phenomenon of comparison is considered as the normative comparison. Fischer (2008) also argues about these two categories of comparison i.e. historic and normative comparison. In historic comparison actual consumption data relates prior consumption data as stated before. Comparison between own consumption to that of others is normative comparison. This could be comparison with an regional average, other groups in the offices, altogether different offices of same type and size (Staddona, 2016).

Normative comparison can encourage specific motives for energy consumption. Such as, ambition and competition. When a comparison of consumer's own consumption to that of others is done, their own position in the surrounding is informed to them which advance their knowledge (FIischer, 2008). Hence customer informedness may relate to normative comparison. In this chapter normative comparison will be discussed. In the Netherlands some services involved normative comparison to their energy efficiency plans. For instance Nuon who make it possible for their customers to compare their consumption with that of other consumer groups (Nuon). In order to classify different aspects of normative comparison, a more detail insight in the normative comparison, Ayres (2009) classifies comparison into three different strategic approaches that can bring change in behavioral intention save energy:

- Comparison with the average consumption or standard consumption (building type or number of residents)

To link this strategy with that of non-domestic buildings, this can be further classified as comparison with the consumption of number of employees in office or with different building types within the office premises.

- Comparison with group of consumers having more or less similar consumption (student dormitories, young families)

Further, in order to get insight in its applicability in office environment, it can be the group of employees, or even the comparison among employees on separate floor (if the number of employees in company is high).

- Peer comparison (family and friends)

Although this strategy of comparison can influence behavioral intention, but the composition of employees in office are related to work and comparison made only between the close friends of employees is thus not efficient.

For the first two categories, literature also supports the comparison in office environment. A systematic study carried out by Staddona (2016) to review the intervention strategies to change behavior and save energy at workplace, emphasizes on comparison as modelling process meaning "*providing example for people to aspire or to imitate"*. This scientific paper indicates that the comparison can be induced in office environment by comparing the employees either individually or in a small groups of 6-8 people. If the number of employees is relatively high then these groups can be formulated even by comparison between the different floors in an office building. This study further states that the comparison of the employees can be realized by bringing employees to share stories either through opportunities for bragging or with the use of electronic displays of energy saving of other colleagues or groups in office or with office average (Staddona, 2016).

2.5.1 Normative comparison

Numerous studies on residential energy use and non-residential energy use indicates that the normative social comparison can have positive impact on individual behavior. A study by Dixon (2015) specifically focused on reducing energy consumption by comparative feedback among the employees in US university by comparing 6 separate buildings. This yearlong campaign at this university influenced the employees to save energy by providing them the consumption information through online platform giving feedback, a website, an email reminder and through posters. This campaign resulted into energy saving of 6.5% per building. The study concluded interesting finding, the outcome of energy use reduction was not the result of change in behavioral intention and pro-environmental attitudes of the employees, but energy saving was achieved with the employee's motivation to outperform their colleagues.

Another intervention in energy consumption reduction undertaken by Kamilaris (2015) at the office of Environment sustainability at Singapore considered the comparison of employees in office building on individual level by providing individual energy consumption data, information and advice. This study underlines the importance of the scale at which comparison or modeling of employees. As the findings suggests, comparison on individual level may have elevated the issue of privacy among colleagues. The participants in this energy saving program also suggested that the comparison among group of colleagues (in different offices) might have been more useful. The intervention resulted into some improvements in employees behavior in the use of their desktop and also some statically significant saving. But the saving were not spastically significant in different phases.

Study undertaken by Siero (1996) emphasizes on reducing energy consumption through comparative feedback. The study comprises of the energy saving intervention between two office units of Metallurgical department in Netherlands. During this study, one unit received information about their own consumption, goal setting and feedback on the possibility of reducing their energy consumption. Along with this basic program other team additionally received feedback on comparison with the other unit. The findings of the study indicates a large impact on the energy wasting behavior of the employees who received additional comparative feedback than the one who was part of basic program. The employees of the unit that received comparative feedback saved more energy than those who received feedback only on their own consumption. The exact figures of

energy saving is bit distributed since the program considered different phases and lasted for 20 weeks.

2.6 Gamification in energy saving

In energy research it is argued that pilots that last longer overall save less energy (Ehrhardt-Martinez, 2010). It is concluded that respondents are more involved in the energy saving conversation in the beginning stage of the pilot as when the pilot evolves. Therefore we argue it is very important to motivate consumers to stay involved with energy saving. In recent literature about smart meters and energy saving it is outlined that adding game elements to an energy program could overcome this problem (Reeves B. C., 2012). Here, gamification is linked with behavioral change.

Also, in the report published by EIC (2014), it is argued that in order to deliver behavior change to improve energy management, it is very important to make employee engagement easy, fun and personalized. And this can be realized by turning to gamification or by using voluntary energy champions (Working Smarter: Realising the potential of smart meters in business, 2014).

Gamification is a trend where digital designers have recently started to incorporate game elements and mechanics to non-game systems, services and applications with the objective of improved engagement of end users (Liu, 2011). This is in relation to the web 2.0 technologies that enables consumers to interact with the system and thus become a content generator. This change in consumer engagement gave rise to research wave surrounding the field of consumer's relationship development with a certain platform. Literature argues that giving consumers incentives can help them change their behavior. Gamification has the ultimate objective to incentivize non-game system user to have a behavior like a game (Liu, 2011). While engaging consumer to obtain behavior change through gamification both social and psychological motivations as economic incentives are of prime importance. (Reeves B. R., 2009)

Social facilitation is a method supported with the gamification literature (Liu, 2011). Social facilitation refers to the tendency that the performance of an individual is better when someone else is observing. On the contrary, people tend to perform less when they work alone. So as to make social facilitation a part of an application, someone's effort should be easily traceable by others and these individuals should keep in mind that their work can also be traced by others. In addition, the exceptional work and contribution of each individual that help in realizing the goal should be remarked. Social psychological incentives such as comparing to the historical data or ranking the contribution of individual or team in comparison with the other participants can significantly increase the time of user's engagement with the platform (Cheshire, 2008). On the other hand, economic incentives are the real money or other commodities that enhances the user's activeness in platform. In household energy saving programs this can be straight forward incentive in the form of lower energy prices or refunds when using energy at off peak times since they can directly coordinated with the energy providers. Game elements have been contributed in various sectors since several years. Best example for this is the frequent flyer program of airline companies that offers their customers elite status depending upon the miles flown.

2.6.1 Gamification loop

The basic ideology behind gamification is to form a gamification loop within the environment of non-game system (Reeves B. R., 2009). Although gamification loop is based on non-monetary incentives, but can have a better relation with the social psychological incentives.

Basic functioning of this system, a clear goal or challenge is put in front of the users and when they achieve this challenge a reward is given. This reward can be in the form of social or economic incentive. For motivating competitiveness, the reward can be given in the form of leaderboard or badges based on the historical achievements. And lastly, the most important is the virtual status of the players in the social network or in the system's network should be updated to stimulate the best behavior. In such platform of gamification, several levels are designed most often. This means when the consumer is upgraded to a higher level when he/she achieves a certain goal.

Figure 8 Gamification loop (Liu, 2011)

2.6.2 Gamification and energy behavior

Literature outlines some researches that links gamification with energy consumption. It is observed from the researches that although many of them haven't use the terminology "gamification", but there are still many that intervenes in the field of energy with the terms goal setting and competition. These elements are commonly used in the gamification literature. In order to get insight in all these terms in the field of energy conservation, we will firstly look into the researches that specifically focuses on the gamification and energy behavior. and secondly, we will look into those concerning goal setting and competition.

Researches in gamification studies how the engagement mechanisms that are most common in popular games can be leveraged to encourage desired real-world energy behaviors among players (Reeves B. C., 2012). Reeves (2011) argues that millions has been spent until now to transform current system into a smart grid, with the idea that making people more informed about their consumption can help them in taking more better decisions in energy consumption which can result into less energy use. He argues that the consumer's interaction with the design of current smart meter system is not engaging. Reeves states that using game like environment to present energy consumption data to the consumers can be a solution to this problem. Consumers can be presented with game like environment elements such as self-representation, virtual connections, goal setting, feedback, levels and rewards (Palmer, 2012).

A very good example of gamification elements in the energy markets is Opower a customer engagement platform under the subsidiary of oracle corporation. This platform is developed to deliver solutions in the form of energy efficient programs to the utilities and households. "Energy consumption is normally not something people usually talk about, but on this app people are talking

– a lot. Users are leaving tips, provide support, share successes and have fun as they challenge each other to reduce their energy usage" (Palmer, 2012). In Opower platform energy feedback feature is added with the game elements. The platform uses real world smart meter data and combines it with socializing, collecting points and receiving rewards for challenges ability. The main objective of Opower platform is to modify customer's energy behavior in real life. This goal is realized by connecting the platform to the real life smart meter in practice. Another such real life example that connects with smart meter and provides consumer's application that uses game elements to improve energy efficiency is the Simple energy. Social elements and the data analytics from the smart meters is combined in this application. Additionally, the application motivates the consumer's to save energy by giving away incentives to win prizes. In a pilot program conducted using this application in San Diego, 3000 households participated in a three month program and on average energy savings doubled compared to only feedback on consumption (Palmer, 2012).

2.7 Goal setting in energy saving literature

Although the energy literature states that the term gamification has not been used widely in this field, still some of the researchers has carried out with the focus on goal setting and competition. In the comparison study carried out by Martinez (2010), 57 energy feedback studies are compared in total. Of them 18 are specifically concentrated on the elements similar to gamification. Among them, 4 are studied using goal setting and 2 using competitions. This paragraph will give an overview of most cited studies.

Staddona (2016) illustrates goal setting as the intervention strategy that has most impactful effect on the pro-environmental behavior. In further emphasizes on goal setting as Incentivasation i.e. creating the expectation of reward. However, this reward has two characteristics, in the form of cash, bonus, food or other prizes and it may also be social in nature i.e. not based on financial and other gains but rather based on sense of social achievement. For example posting a positive descriptive comment on employee's review page. These social rewards are given on the basis of attaining the target or pre-existing goals in the form of their performance for energy saving actions. However, goal setting with no reward is also a form of incentivisation (Staddona, 2016).

Nilsson (2015) indicates goal setting is based on the thinking that the human behavior to save energy is goal directed and the eagerness to achieve this goal consists of the motivational effect. In addition, the articles mentions that the goal needs to be set high, yet attainable and realistic to be effective. Goal setting to be significantly effective should be in addition with the feedback. Nilsson (2015) conducted an energy saving intervention with the combination of feedback, goal setting, information and prompts among three different departments of an office building in Gothenburg, Sweden. One department only received the information about the suggestions on how to reduce energy in offices and the other two teams were provided with prompts, feedback and goal setting to achieve energy saving of approximately 8% on electricity and 15% on printouts. The intervention lasted for four weeks and at the end of intervention all the groups achieved energy saving. However, the energy consumption of group with goal setting decreased by 5.5% for electricity and 3.9% for paper and the group without goal setting achieved 12.9% energy reduction and 8.3% less use of paper which was not in line with researchers prediction.

A light saving campaign launched by Ministry of Energy, Mines and Petroleum Resources (MEMPR) combined goal setting using communication and feedback highlighting goals and tracking progress on bright colored charts placed in common lobbies, prompts, empowering champions consisting the proactive participants to interact with other team members and share knowledge, norms and persistence of saving establishing new norms for energy conserving behavior. The interventions analyzed the energy saving statistics for three floor, one with automated daylight systems, second with individual light switches and third floor is considered as baseline. A goal of determining 10% energy saving was imposed. The results showed the positive effect on energy saving with the base line floor accounted for only 2.4% energy saving, the floor with individual switches accounted for 12.0% energy saving and the floor with automated daylight dimming reduced energy consumption by 12.6% (Owen, 2010).

The importance of goal setting in realizing energy saving can also be traced from few researches in the household sector. Although this research focuses on office buildings, insight in the interventions using goal setting in domestic building can help in realizing its potentiality. McCalley (2002)argues that goal setting can have a significant positive effect on the energy saving if undertaken in energy saving program. The outcome of the research conducted by Houwelingen (1989) indicates that the providing household with specific energy conservation goals can realize more energy saving compared to providing households with only feedback on energy consumption. During this specific research the goal to save 10% gas was outlined and the participants who knew this goal accounted to energy saving of 12.3% more than the participants who only received feedback.

2.8 Competition in energy saving literature

Competition is recognized as a medium to generate motivation to reduce energy consumption by giving rewards or incentives. Metzger (2011) conducted study to encourage the employees in work place to save energy by competition, although with no tangible rewards other than social recognition. In the experimentation study, the employees were provided their electricity use and the carbon dioxide emission on a group level comprising on 6-8 employees in each group. The information was made available through an online digital dashboard displaying the information of all groups alongside each other. The study realized energy saving of 6% over the period of 4 weeks.

In an energy saving intervention undertaken by Handgraaf (2013) analyze the energy saving by giving different types of reward namely publically, privately and socially between 5 departments of Dutch environmental consultancy firm consisting of 83 employees. These employees were divided into three groups namely monetary vs. social reward, private vs. public reward and a control group with no reward motivation. The results indicates that the rewards given publically outperforms those given privately. It further adds that the social rewards comprising receiving grade points with a descriptive comment outperformed monetary rewards (up to 5 Euro). Subsequently, the public social rewards proved to be successful in achieving energy consumption reduction of 6.4% whereas privately given rewards increased the energy usage.

Another study specifically focusing on competition using an online game called iChoose engaged groups of employees in competition. This intervention was basically undertaken at office level but its scope was widened to home environment as well since the employees were encouraged to record their energy saving with regards to their activities at home and doing so enabled them and their team

at office to receive points. The competition included some rewards such as small monetary incentive for the leading individuals and a team prize at the end of the game. And this experiment resulted into electricity saving of 463 megawatts (Kuntz, 2012). Another interesting study conducted by Orland (2014) considering competition created and trailed an online game platform called “Energy Chicken”. In this study the health of chicken was programmed in such a way that it would determine the plug load energy use of the employees. The results of this study showed significant positive impact on energy saving by reducing it to 13% out of which 23% was realized over weekends and 7% on weekdays and 69% of the employees gave feedback of getting motivated and increased awareness to save energy with this intervention.

To shed light on interventions using competition as an element for gamification, some related researchers in the residential type environment is also studied. Two studies determining energy saving using competition are found. Both the studies are explicitly based on student residences. In one of the studies competition between 18 student dormitories is aggregated with providing real time feedback (Petersen, 2007). This study took place for two weeks in which the students were put into competition using an automated data monitoring system, through which they receive the web based real time feedback in order to realize reduction in resource use. Students were motivated to outperform in this competition by introducing reward on conservation. The outcome of this competition resulted into energy saving of 32%. The winning student dorm was given an ice cream party as reward. However the attendance for this party was very low which assisted to conclude that the attitudinal factors other than receiving reward for the competition was the main driving force to realize this energy saving. The conclusion of this research also emphasized that the challenge itself in addition to the social interaction involved to accomplish this challenge was more important in motivating to reduce consumption that receiving reward.

In another such intervention carried out by Geelen (2012), competition between student households in Netherlands was introduced through game “the energy battle”. During this intervention, student household received direct feedback on their energy consumption along with some added game features such as ranking the teams competing, tips and access to energy battle game. This resulted into energy saving of about 45% for the most efficient houses and the average electricity saving of 25%. However, after the experiment the energy consumption increased but still remained below the level observed before experiment.

2.9 Data apportioning and visualization

2.9.1 Apportioning energy consumption to occupants

The insights in applying social psychology to non-domestic energy saving behaviors are very sparse (Bedwell, 2014), still some literature traces down the interventions offering potential steps for organizations to initiate measures that would more actively participate their staff in workplace energy savings. Research exhibits the approaches that involves distinct feedback based on energy data are exceptionally effective (IEA, 2007; Bin, 2012). Data that permits energy consumption to be distributed over the occupant are ideal in facilitating the process of psychological and social mechanism that have been demonstrated to influence behavior. Especially social control and cooperation, and instrumentality and self-efficacy (the feeling of your own action makes a difference) (Bedwell, 2014).

Distribution and monitoring energy consumption facilitate the goal setting for reduced consumption resulting in important motivational effect on groups and individuals. Setting of goals enhances action by focusing individuals effort and attention towards the desired goal. This can be obtained by energizing the individuals to try to attain the goal, encouraging persistence in behavior that perform towards the goal and by encouraging the invention of new goal relevant information and strategies (Houwelingen, 1989; Bandura, 1983). Additionally providing occupants feedback on their energy consumption enables them to understand how they are proceeding towards the goal, and this combination of feedback with goal can be more effective than goal alone. Also the interventions carried out using this combination has resulted in to 5-12% of energy reduction in the residential setting (Abrahamse W. S., 2007; Houwelingen, 1989). This implies that the effective way to reduce energy consumption in office setting is to adopt explicit energy goals within company strategy and make associated energy data available to every individual using some visualization medium such as public display or personalized energy feedback.

With apportioning the energy consumption to occupants and making them visualize it, may also enable them to compare their energy usage to that of others. However, the number of occupants varies in different settings. Organizations and workplaces are likely to have many more people than in the residential settings, therefore, the effects for distributing energy data to different configurations of building users are complex. Bedwell (2014) outlined the mechanism of apportioning of data in workplace environment by reviewing the two categories : apportioning energy data to individuals – which requires the disaggregation of data on finer level or group of individuals

Apportioning energy data to individuals vs groups

Disaggregating energy saving data on an individual level can realize promising benefit by making individuals engage in tailored energy saving programs. In accordance with this the researches in social and behavioral research argues that providing the personalized information can significantly result into behavior change of the employees (Abrahamse W. S., 2005). As apportioning feedback on individual level underlies the fact that this can reveal the personalized information into public either accidentally or by the design of the energy saving program and ultimately forming a base for comparing among other peers (Bedwell, 2014). Peer effect are often considered to have potential effect while pursuing behavioral change and in line with this researches indicates that sustainable behavior are often motivated among the individuals when they are encouraged by the peers and when this behavior is visible to peers. Descriptive norms are said to take place in such situations where knowing the behavior of others towards energy saving concern will most likely effect on the individual resulting into following these norms and act similarly (Cialdini, 2003). These descriptive norms can also have negative impact for instance if it is observed that others tend to use more energy, then this may affect energy consumption of people resulting into using more which is also recognized as boomerang effect (FIischer, 2008). Similarly, a culture may prevail where employees perception of environmental goals are nonproductive then other goals ultimately leading them away from desire to save energy. in such situations injunctive norm appears which are what other people think you should do and this may discourage energy conservation (Bedwell, 2014).

Additionally apportioning data on individual level can also result in lateral control and peer scrutiny leading to animosity i.e. dislike, hatred or enmity between individuals (Ellway, 2013). Moreover in some of the work environments where the basic work unit is a team that uses appliance and systems

collectively, apportioning energy data on individual level may be very complex. Additionally, the possibilities of an individual feeling procedural injustice when energy data is apportioned on individual level is unfair or unachievable (in case of goals) while comparing with others. This can lead to reduced efforts of individual in energy saving as a result of perceived injustice causing resistance of individual (Bedwell, 2014).

On the other hand, when the energy data is distributed on a group level it may have certain advantages to that apportioned to individual. With a formation of group of employees, factors such as group dynamics, motivations can determine increased contribution in group energy saving. Grouping of employees even by arbitrary means are likely to get associated with that group and act to enhance energy saving which ultimately enhances their group image (Tajfel, 1970). Therefore, the organizations with simple composition of employees according to spatial location, by introducing additional facts such as group identity and norms can thus result into enhanced effects on energy conservation. Moreover, monitoring metering data of the group co-located in certain space is also comparatively easier as technically and financially monitoring electric circuits of the appliances and systems used by group together is smaller as compared to that at individual level (Bedwell, 2014).

Spatial composition of employees within an organization or often related to team membership. Also composition of employees into random groups for instance spatially dividing them by sub-metering, by grouping of employees with organizational social relationships i.e. grouping employees into teams or friendship groups can induce social effects resulting into increase in social identity felt by group members and group dynamics (Cameron, 2004). Making group more cohesive thus relates to more social-bonding and effect ultimately encouraging them to work together for the goal and thus they are less likely to freeride. Group ties in such groups may also lead to taking social actions such as campaigning for more sustainable instrumentalities or purchases only if environmental concern is valued by the whole group (Bedwell, 2014). Therefore, grouping of employees based on pre-existing communities or spatial locations can be more beneficial is all aspects to contribute more in energy saving.

2.9.2 Data visualization

Various studies has shown the positive impact on energy saving using various different approaches which are also discussed in various literature sections above. Many of these researches, along with using behavioral change mechanism also focused on the making the energy consumption visible to occupants using personalized energy saving applications, information displays in public area, interaction with consumers using emails, billboards, web based interface, prompts etc. Even though these researches has used some kind of feedback provision mediums, they lack in presenting the detail information provided to the consumers, as also stated by Fischer (2008). There are various alternative ways of providing information to the consumers that can have impact on their energy saving behavior determining reduction in use of energy. Wood (2007) gives the summary of options that can be used in providing energy consumption, especially in the household environment as shown in figure 9. Although these are somewhat focused on residential typology, the understanding in its applicability can prove to be helpful in the non-domestic domains as well.

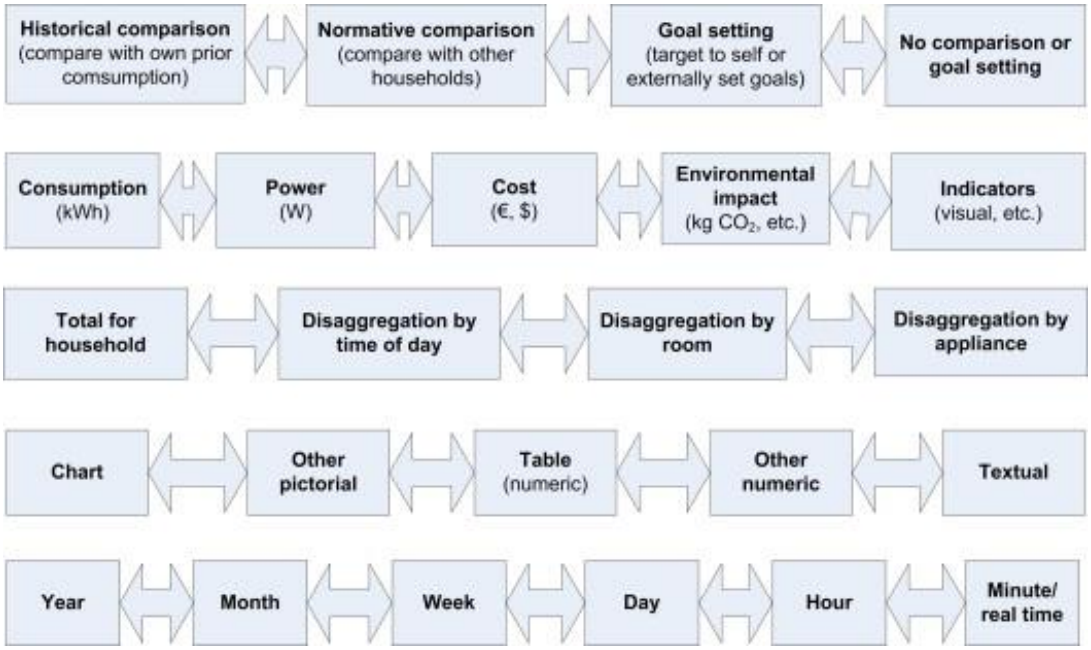


Figure 9 Summary of options for presenting feedback (Wood, 2007)

Comparison and goal setting feedback

As discussed earlier, the provision of feedback on comparison and goal setting can be useful in determining occupants energy saving behavior. Using historic comparison i.e. if they compare their current consumption with that of prior consumption. Also presenting occupants their prior comparison is considered as common of presenting feedback. Additionally, the facility to provide historic comparison is available in almost all energy monitoring solutions. Roberts (2003) also states that consumer can easily interpret their historic energy consumption. However, weather differences can bring hurdles in the smooth functioning of comparison. As the climate changes, the consumption also tends to change in accordance to the situations, for instance if the electricity is used for space heating it can have major impact on consumption in places such as Finland. In such situations historic comparison can therefore be not useful since they only consider the differences in the time period and not the weather differences in the year (Karjalainen, 2011).

An alternative to this, can be normative comparison i.e. comparing own energy consumption to that of others. It is already discussed the potentiality of normative comparison in section 2.5.1. The data to compare with can be easily retrieved from the data bank. Providing comparison to more similar characteristics of buildings or occupants, more relevant information can be provided to compare since there are number of characteristic that need to be considered while comparing such as year of construction, floor are, number of occupants and climatic conditions (Karjalainen, 2011). According to Robert (2003) if the comparison of the occupant group finds their consumption above average consumption, they get motivated to reduce it. However, if the comparison shows that their energy consumption is already lower than the others or average, then the questions arises : whether they are still motivated to save energy? Because they may have the feeling that they have done enough and don't feel the need to alter their behavior even if there is room of energy saving. In such cases rewards can be very helpful to motivate them continuing energy saving. This reward can be in any form suitable to the case and situation. Karjalainen (2011) states that with development in energy feedback software, new features can be incorporated such as reaching advance level as it is seen in

computer games of unlocking next level. Although the level of effect of these software is not yet completely known in the environmental and energy studies but does surely has the potentiality as it is observed in the competition section in this literature review. Additionally, as it is already discussed the potentiality of goal setting in reducing consumption in section 2.7, to bring this feature in energy saving program, it is very important to have tools that can monitor their consumption of the period they attempt to meet the target. Additionally, suggestions on meeting the target and providing reward can have motivational effect.

Power, cost and environmental feedback

Subsequently, presenting consumers information with power used, cost of using power and environmental impact information can further add to energy capabilities mentioned above. Presenting information about energy consumption can be realized using many different units. The very basic units that is also mentioned in energy billing is the kilo-watt hours (kWh). 1 kWh of electricity is consumed if an appliance operating at 100 W is used for 10 h or an appliance operating at 1000 W is used for an hour (Karjalainen, 2011). However, people have very less understanding of the scientific units (Wood, 2007), although the calculation above shows an easy understanding principle. i.e. kWh is an unit directly related to power (W) and time for which it is operated (h). Making people understand the calculations can enhance their understanding. Alternatively or additionally, units consumed on monetary basis can also be included in the visualization process since people are more familiar with the monetary units (Karjalainen, 2011). Considering the ultimate purpose of providing feedback to reduce energy consumption, providing feedback on monetary basis is sensible. However, this approach can be useful in household setting where residents are themselves responsible for consumption and paying their own bills. But in case of reducing consumption in office buildings this can have lower impact since employees are not related to paying for energy consumed. Also the energy consumption information can be provided in the form of environmental impact for instance carbon dioxide emission in kg. As the intention to save energy along with reducing energy bills also lies with the contribution in reducing greenhouse gas emission. And environmental impact fairly depends on the source of energy as well as kWh, this method of presentation can prove to be valuable in for understanding environmental impact of own energy consumption. However, people are still unfamiliar in relating their consumption with environmental impact presentations for example Karjalainen (2011) states that people cannot even roughly estimate how much carbon dioxide is emitted by a household every month due to electricity consumption. Researcher further adds that presenting some kind of comparative data along with this can give them relative idea about emission level.

Disaggregated feedback

Another method of providing meaningful feedback about energy consumption is disaggregation. In the previous section the disaggregation of energy data in office environment by apportioning to groups and individuals is already studied. However, some more factors that can have significant contribution also exists. Fischer (2008) states that disaggregation can also be provided by time, by room and by appliances. However, provision of feedback on time of day and week can be more appreciable for the consumers who pay energy bills based on time and week dependent tariffs schedule. Disaggregation by room may provide additional information as to which room is consuming more energy. Another important factor that can also be very useful in office setting is the disaggregation of energy data on appliance level. Usually meter provide the information on the total

consumption, however if this information can be further divided on how much each appliance use, it can give the users the information about which appliances are consuming more energy and they can further regulate the use of those appliances and systems by their behavioral actions. Fischer (2008) states that design which provide detailed, appliance specific breakdown are linked to the achievement of the greatest saving.

Graphical, numerical and textual feedback

It is very clear that the methods used for presenting energy consumption data to the consumers affects how the data is understood and the attractiveness of the system. and this in turn can certainly has an significant effect on the energy saving realized. However there are lack of studies researched that explicitly focuses on the issues of how to present feedback on energy consumption (FIischer, 2008). And the researches that has considered this issues are mainly focused on energy billing design then the interactive system design. However, some inferences relevant to this research can be studied from these bill designs to get understanding of various mediums of providing feedback. The conclusion of the study by Baker (2003) focusing on bill design states that combination of text, diagrams and tables were found to work more effectively than single format presentation. Graphical presentations were favored but text labels were needed to assist the understanding. Additionally Smith (1986) created a large set of guidelines for the design of user interface software. The following list gives the summary on their guidelines that are relevant to the energy consumption feedback.

- Displays should be designed carefully by only providing necessary and immediately usable data, and do not overload displays with extraneous data.
- Display of the data should be in a directly usable form, do not make users convert the displayed data.
- Energy data should be displayed with standards and conventions familiar to users and words to be displayed should be chosen carefully and then should be used consistently.
- It should be ensured that clear visual definition of data fields are provided so that data are distinct from labels and other display features.
- Graphical presentation should be considered instead of textual description to display data showing relations in space or time.
- Pie charts should be chosen only in special cases to show the relative distribution of data among categories but it should be noted that bar graph will permit mire accurate interpretations for such applications.

Time scale

Energy consumption information such as kWh, average usage, $, kg-CO2 can be provided on yearly, monthly, weekly, daily or hourly basis. Preferably the users should have the opportunity to choose the time period of interest (Karjalainen, 2011), however it completely depends upon the energy saving program considerations. Moreover, advancement in metering system such as smart meter it is also possible to show the rea time measurement such as watt.

In a study undertaken by Karjalainen (2011), researcher showed the consumers different visuals considering above mentioned feedback alternatives and the guidelines. The study constructed 8 visuals as shown in figure 10 and were distributed among the respondents to select from the visuals that motivates more in energy saving. However, the screenshots are prepared with the focus on

residential energy reduction intention, the results of the study can be helpful in setting up the survey for this study which is related to reducing energy consumption in office buildings.

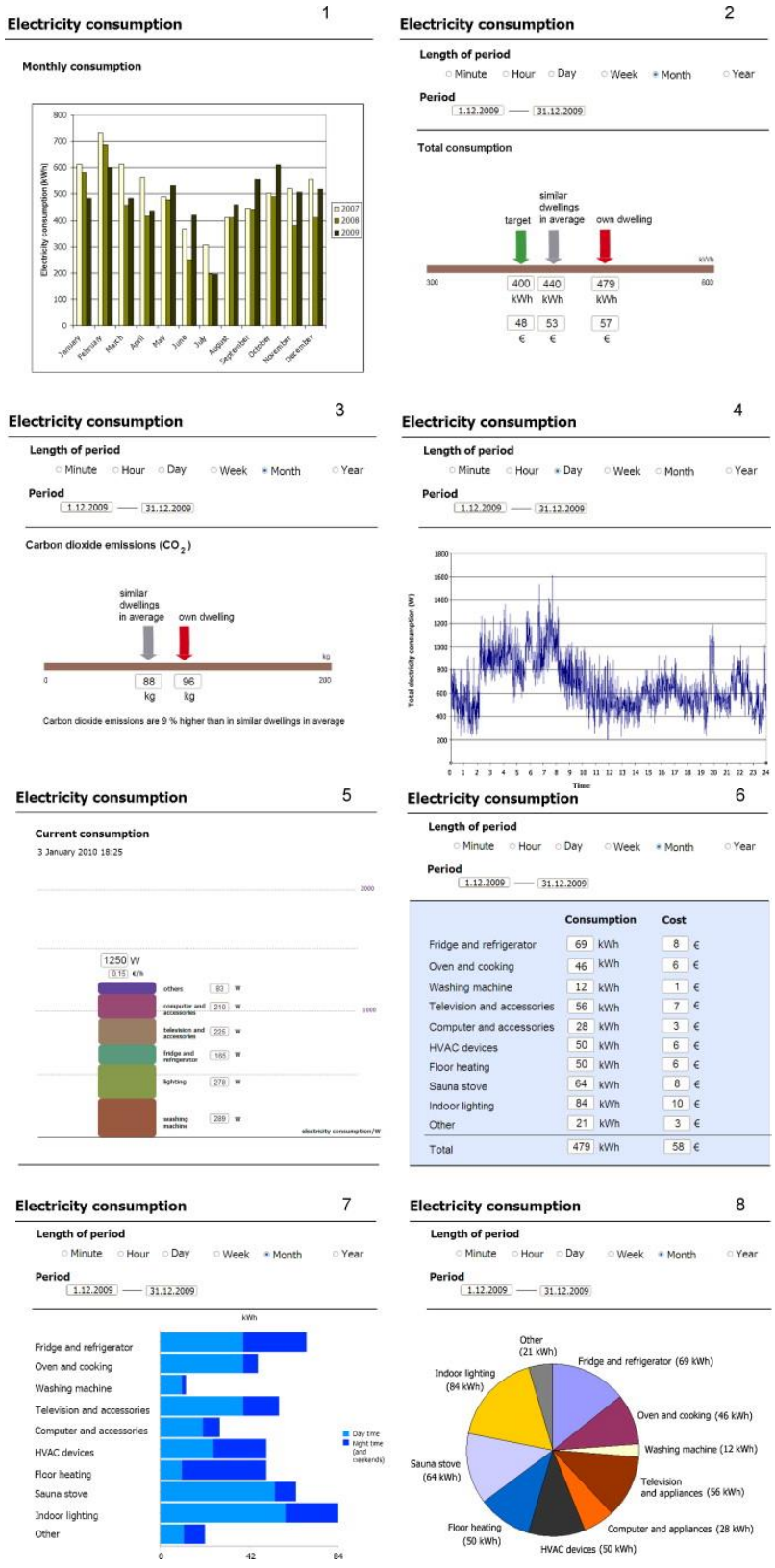


Figure 10 User interface prototypes (Karjalainen, 2011)

This study only included 14 participants and estimated their understanding for different screenshots. However, the conclusion of the study shows almost all the participants understood all the screenshots presented to them but the prototype 6 showed interest for the majority. All the variants in this study were designed by the user interface expert therefore all the variants are important and this study will review the most appropriate and choose and customize according the situation and case this study is intended to.

2.10 Relation of socio-demographic characteristics and attitudinal factors with energy concern

2.10.1 Socio-demography characteristics

Socio-demographic factors are defined as the characteristics essential to determine the sociological and demographic factors. Various researches in the field of marketing, social science and other studies uses these factors for analysis. Sociological characteristics provides the researchers information about the social relation of the participant, for example composition of household, membership in organizations, social groups and values. On the other hand demographic characteristics are more of the facts related to person, for example age, gender, place of residence or level of education.
Combination of both the factors will help to gather background information of the participant. Based on literature, the factors are connected to the environmental behavior.

Gender

In any research, gender of the participants play an important role in understanding the opinion about the two categories (male and female) for the projected study. Researchers (Diamantopoulos, 2003; Roberts, Green Consumers in the 1990s : Profile and Implications for Advertising, 1996; Bernadette S. B., 2011; Rowlands, 2002; Straughan, 2006) related to environment and energy arguers that the women considers the impact of their action on others more carefully. In other words, literature states that women when compared to men are more concerned about the environmental and energy issues. While studying the reason for this difference in the perspective, the characteristics of personality traits, attitude, skills, altruism, personal responsibility, empathy in women are considered more important than men (Polakovic, 2012). They also describes environmentalism as important in protecting themselves and their families. However the findings based on gender are still non-conclusive as most of the researchers found the effect of gender on energy use to be statistically insignificant, minimal and inconsistent, it is still considered in the study in order to analyses the differences in opinion.

Age

Age is another socio-demographic characteristic as important as gender. Some literature indicates a positive association between energy usage and age. It states that the energy consumption increases as a person grows older. Therefore, it can be said that younger people are considered more sensitive towards green issues compared to the elders (Bernadette S. B., 2011; Diamantopoulos, 2003; Rowlands, 2002). However, this positive association also has the limitation of consistency since some researchers did not find any statistically significance or even indicating that older people have more energy saving concern and committed to sustainable energy use as compared to young. Relating with the energy consumption in residential buildings, some studies has also proposed that the relationship of age and energy saving are curvilinear. These studies indicated that energy consumption is

maximum among the middle age group living in bigger household with higher energy requirement and conversely young and old aged people living in small households still having high energy use and take fewer energy saving actions than those in middle age group (Frederiks, 2015). Straughan & Roberts (2006) found the relation of green attitude and behavior based on depression-era conservation and behavior originating from a charitable and social activities among the middle age people. An interesting argument mentioned in the study was the time people who grow up in the time period with energy saving concern, they still considers this as an important issues and hence act with sensitivity towards environment.

Level of Education

Some studies have indicated the significant influence of the level of education on the pro-environmental behavior and energy saving concern. But higher education does not directly results in increased pro-environmental behavior. Instead they indicate that there is a "knowledge-action gap" across various different human behavior. This gap is not only limited to pro-environmental behavior but also with concern to energy consumption. Nevertheless, numerous researchers (Bernadette S. B., 2011; Diamantopoulos, 2003; Rowlands, 2002) argued, higher the level of education, more is the realization in energy saving and participation in energy saving programs. Hence, level of education is also considered in this study in order to observe if there is any statistical difference.

Geographical work location

In the past few decades, the realization of the need to save energy has been increased on tremendous level. Various geographical locations such as European Union , United States of America, Asia etc. has undertaken serious implications to minimize the energy use in all the sector (Wikipedia, n.d.). While this wave of energy conservation is spreading throughout the world, it is interesting to study the feedback of people working in different regions to save energy through smart meter data. Additionally, in a book by Cheng (2011) it is emphasized that scientific knowledge has been developed in, and is rooted in Western countries. It further states that this scientific knowledge in the field of law of energy conservation, energy transformation and degradation in non-western countries has been translated from western languages which can create gap between their understanding and the culture of development of conceptual knowledge. Therefore, in order to determine if there is any significant differences in the knowledge and understanding of people from different region which can have impact on human behavior towards pro-environmental behavior and social-interaction determining energy conservation, socio-demographic characteristic work location is considered in this study.

Work sector

As this study mainly focuses on saving energy in office environment, this characteristic is introduced in questionnaire to weigh the importance of different attributes considered in the study. Simply considering study for office environment without considering employees with different fields of expertise is not justifiable since people working in different background have different usage of energy and their approach to reduce it can be different from both professional and behavioral point of view. This study considers people only having work station in a particular office, the people working in industrial sector are exempted from the study. In order to determine different possible work sectors this study can be related to, job profiles from the general demographics questionnaire are considered (General Demographics Questionnaire).

2.10.2 Linking theory of planned behavior with attitudinal factors

Behavioral attitude as attitudinal factors

Theory states that the people's behavior is influenced by the behavioral attitude an individual has towards the behavior. Behavioral belief is the person's approach to perform the behavior considering the target behavior. i.e. when the target behavior is evaluated as positive, person's intention to perform the behavior will be higher and they will be more inclined to do so (Pavlou, 2006). Similarly attitudinal factors are nothing but the connections between attitude and the behavior. It can be describes as "a psychological tendency that is expressed by evaluating a particular entity with some degree of favor or disfavor" (McClaren, 2015). In the field of energy conservation numerous studies has been conducted to analyze psychographic correlations of green attitude and behavior. These studies has enormously put forward some alluring observations into the nature of green consumer. Therefore, to construct the frame for attitudinal factors in the study, some important factors such as perceived customer effectiveness and ecological concern are described. In the questionnaire, these factors would be introduced to respondents in the form of 5 point Liker scale.

Control beliefs as Perceived customer effectiveness

In TPB control beliefs deals with the individual's beliefs about the existence of factors that may facilitate or hamper performance of the behavior-adoption (Theory of Planned Behavior, n.d.). It is influenced by the easement by which a person can execute the behavior or his/her thought of executing the behavior. On a similar notion an extent to which an individual believes his/her ability to affect environmental resource problem is determined by Perceived customer effectiveness (PCE). Researchers through their studies straight forwardly arguments that consumer's attitudes and response to environmental appeals are a function of their beliefs that individuals can positively influence the outcome to such problems (Rowlands, 2002; Roberts, 1996). The consumers who shares consciousness within a society have firm confidence that they can encounter the problem of pollution and they always attempt to contemplate the social impact of their purchases (Webster, 1975). Although, the study focuses on changing behavior intention to save energy through smart meter data, the questions based on PCE will help to understand the difference in respondents way of thinking for energy reduction. This question will be asked on 5 point Likert scale and it relates the energy behavior of offices at the location they are working at and their part of energy consumption compared to the total amount. Question asked can be found in appendix A.

Subjective norms as communication

Furthermore the normative beliefs deals with the person's perception of social normative pressures. This perception is influenced by the opinion of significant or important people to them such as parents, spouse, friends, colleagues etc. which helps them to take decision whether to perform or no to perform the behavior. Therefore, communication can be linked with subjective norms as it is all about receiving suggestions from socially conscious consumer involved in the community. People who tend to have more inclination towards green behavior often talk about their energy consumption pattern and behavior and also frequently discuss with others about energy and environment issues and the possible ways to achieve greener environment (Rowlands, 2002). Therefore to overview the respondents based on these socialization factors, question regarding the frequency of their discussion with other to reduce energy consumption is asked.

Ecological concern

Ecological concern highlights the relationship between the attitude and behavior and it has been researched in various different backgrounds. In studies related to environment and energy, it has been explored as a relation between concern towards environment, attitudinal construct and various behavioral measures. Individuals perception towards environment and their attitude for the ecological concern was realized for the essential change in society in accordance with the sustainable development. Ecological concern has been criticized as an interrelation of environment friendly behavior by researchers and realized a positive relationship between them. Through human history Environmental impact has been found as immense consequence of human desire for the physical comfort in the form of family, mobility, status etc. and for the technologies and institutions created by humanity in order to determine these needs (Roberts, 1996). This evolution in terms of development gave environmentally compelling behavior a second meaning. Therefore, ecological concern from the actor's point of view can be determined as behavior that is significantly considered as intention to change from normal behavior to benefit the environment. To describe the term ecological concern in relation to this study, it can be said as concern towards environment in accordance to the social responsibility. Therefore, the individuals who bear environmental consciousness can account to higher ecological concern. Therefore, to identify the respondents bearing this attitude questions regarding ecological concern are introduced in the survey. Questions regarding their concern towards energy saving and their pattern of performing activities with energy saving concern are asked.

2.10.3 Hypothesis

As observed from literature, pro-environmental behavior and concern regarding energy saving may vary between people considering their socio-demographic characteristics. Therefore, in order to determine if there is significant differences between their concern, behavior and awareness for the energy and ecological issues, which can shed light on their intention to save energy, some hypothesis are constructed that will be tested from the data gathered from respondents. These hypotheses are constructed based on the findings from section 2.10. Abrahamse (2011) argues that intention to save energy highly depends upon the concern and awareness of energy and environmental issues. Hypotheses constructed ae as follows:

Hypothesis 1 : Women are more considered about the environmental and energy issues and therefore have higher intention to save energy.

Hypothesis 2 : Highly educated older women are more engaged in energy issues and therefore the intention to save energy is higher among them.

Hypothesis 3 : Youths are more likely to be sensitive about environmental issues and therefore have higher intention to save energy.

Hypothesis 4 :Highly educated people are more concerned about the impact of their action on environment, hence possesses higher intention to save energy.

Hypothesis 5 : Western people may have different preference than non-western people regarding energy issues and therefore have higher intention to save energy.

Hypothesis 6 : Preferences can vary among people from different work sector.

2.11 Conclusion

Detailed insight in the literature review clearly showed the relation between energy conservation and human behavior has the potential to reduce energy consumption. Although enormous literature are available on reducing energy consumption in households, inferences from them can help in detailing out energy saving program tailored for energy saving in office environment. There are various different approaches undertaken in both residential and non-residential environment with the common aspect of changing human behavior in relation to energy consumption. The aims of this research was to get insight in this aspect and understand the complicated relationship between human behavior and energy consumption and implement this knowledge in the field of energy studies with focus on office buildings.

The necessity to save energy has driven the researches focus in this field enormously. Few of them also stated that this necessity does not lies only in the residential buildings but also in the non-residential type of environment. Although the smart meter and smart grid implementation has not considered non-residential energy users such as corporate offices in their implementation plan, the features of smart meter to provide desired information itself has the potential to serve this purpose even if infrastructure is implemented on building level. Moreover from various studies in residential buildings, hostels and dormitories, office buildings, universities using various different approaches such as feedback, comparison, competition, goal setting, gamification shows the potential of these information characteristics, consumer informedness, social mechanism such as social-interaction factors on determining energy saving behavior, the impact of its implementation in office environment would be interesting to observe. Additionally, all these factors has been used either individually or in combination of feedback, this research will shed light on all these studied factors by combining them and implementing in the energy saving study intended for this research. Also, very few literature indicated the use of smart meter in carrying out study, now that the potentiality of smart is studied, this brings an opportunity to integrate the above mentioned factors using smart meter so as to generate smart meter information and contribute to investigate in this vague field of ecological studies with a specified focus on determining change in behavior consumption in office buildings.

Additionally, literature reviews highlighted the possibilities of disaggregating the energy information on various levels such as buildings, groups of employees, individual, appliance level and also highlighted the visualization strategies that should be considered while designing the user interface for the energy saving program. Also, as observed in the last part of literature review, the attitudinal factors and ecological concern can vary among individuals considering their socio-demographic characteristics. And as these factors relates to the intention to save energy, therefore, the attitudinal factors and ecological concern inherited by different individuals can determine impact on behavioral intention on energy saving variedly. Taking into considerations all these aspects, an efficient energy program that can have impact on employees behavioral intention to save energy would be constructed and evaluated with the sample group of respondents working in the office settings. The conceptual model that will consider all the aspects studied during literature review is constructed in figure 11 with focus on most important and applicable elements for the office type environment.

2.12 Conceptual model

Conceptual model shown in figure 11 illustrates the composition of concept intended to study in this research. Blocks in purple color are the pre considered elements considered in study through the literature review. Choice experiment block consists of the factors outlined from literature and are considered to evaluate their impact on behavioral intention of employees in office buildings to save energy. The flow for this particular block is assuming hypothetical situation that the energy data is generated though smart meter and is apportioned on group level. Further this data is processed using the data disaggregation methods indirect feedback and direct feedback, along with comparison which together forms the consumer informedness, in addition with gamification elements that can generate social interaction among the employees. And this processed data is assumed to made available through energy saving application. Later, data visualization (orange) block emphases on the feedback information is shown to the consumers and the impact of complete process on behavioral intention to save energy is analyzed.

Also as observed from the literature, socio-demographics characteristics of the individuals inherits certain attitudinal factors based on which their concern for energy and environment can be determined, which further has impact on their behavioral intention to save energy. Therefore, to analyze this impact, the block with descriptive analysis comprises of process where impact on behavioral intention to save energy is evaluated with respect to ecological and environmental concern (blue) based on attitudinal and behavioral factors from theory of planned behavior (light blue) that is determined by the socio-demographic characteristics (yellow) of the individual.

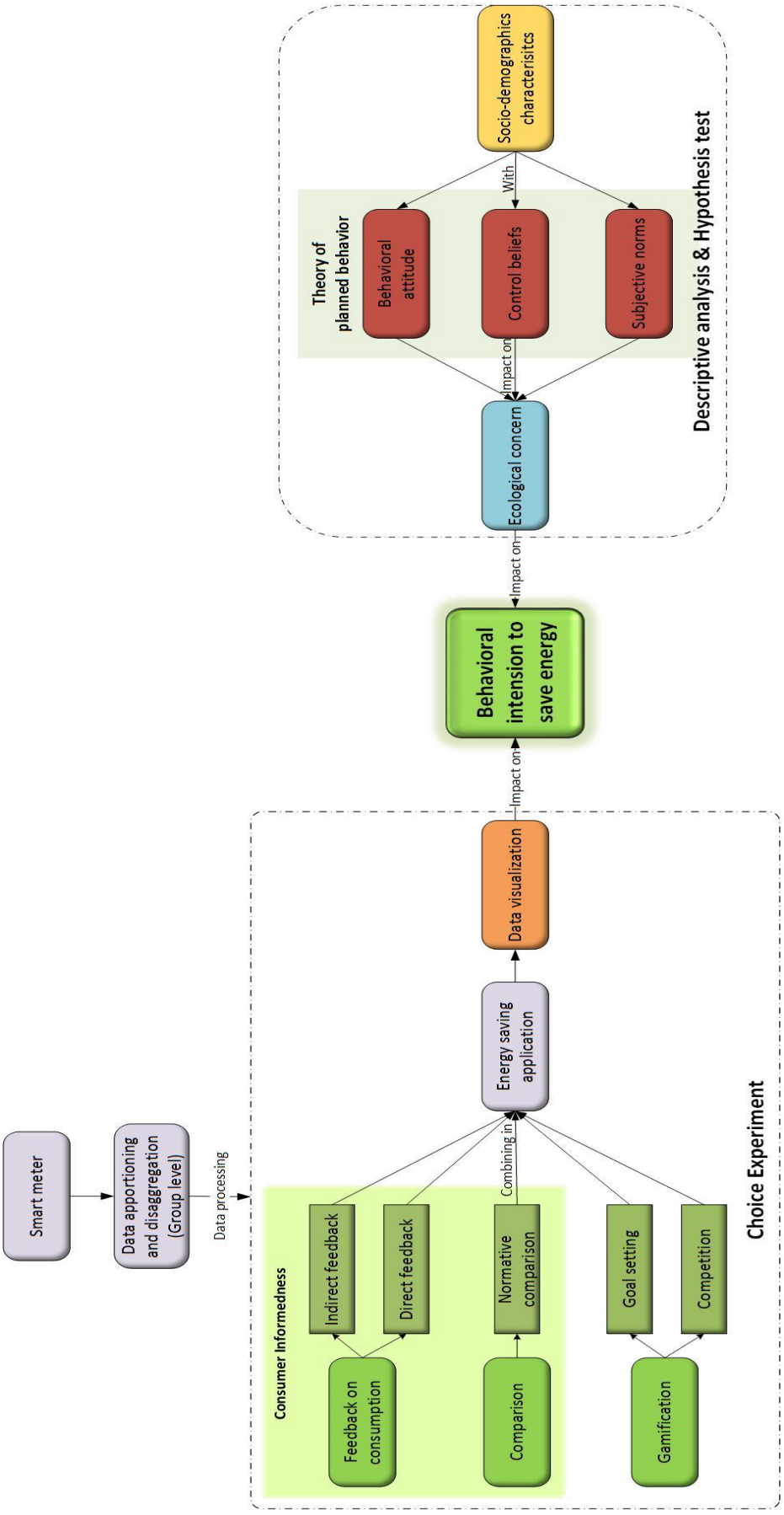


Figure 11 Conceptual model

3 Methodology

3.1 Introduction

The chapter emphases on research approach that is chosen to answer the research questions outlined in chapter 1. As observed in the literature, intention to save energy depends on various aspects such as pro-environmental behavior, feedback characteristics, social mechanism and interaction factors, data disaggregation and apportioning techniques, data visualization strategies, attitudinal factors and environmental concern factors based on socio-demography characteristics. Therefore, it is very essential to select the appropriate techniques to analyze these various factors in determining energy saving intention. As outlined in the conceptual model, descriptive analysis will help in determining the impact of socio-demographic characteristics in relation to attitudinal factors and ecological concern, on energy saving intention. Following this the stated choice experiment will help to evaluate importance of feedback characteristics based on data apportioning and disaggregation techniques, social interaction factors such as gamification, comparison as a consumer informedness factor, feedback visualization on behavioral intention to save energy.

3.2 Descriptive study

Profiling the respondents based on socio demographic seems less appropriate but can be used to identify segments within the office environment. Moreover, socio demographics and personality characteristics of the individual that represents their general characteristics independent of energy conservation issues as they influence general behavioral patterns rather than specifically energy-related behavior, but also indirectly affect energy consumption (Bernadette S. B., 2011). “Socio-demographics are theoretical dimensions of environmental consciousness domain and form the framework to create profiles of the participant” (Diamantopoulos, 2003). However, knowing the socio-demographics of the participants is not enough since the statements regarding the exposure and knowledge of green issues, attitude and behavior toward environment is also important to know. Hence, before conducting the actual choice experiment, the information regarding attitudinal and socialization factors is also essential. Descriptive research can be very useful in defining this since it gives the opinion, attitude or behavior held by a group of people on a given subject. Therefore, in order to determine the impact of attitudinal factors, physiographic, behavioral criteria and ecological concern on intention to save energy according to socio-demographic characteristics of people, various hypothesis are created as see in section 2.10.3, and this approach will be used to find if the hypothesis created are valid or rejected. Using descriptive study the answer to the research question: *How does the energy consumption behavior of employees in office type buildings look like ?* will be realized.

3.3 Stated choice experiment

This section illustrates the methodology that has been used in this research in order to find the answers to the research questions*: Which variables can be implemented in the energy saving applications so as to generate feedback for the consumers in a meaningful way?* & *How can these variables useful for energy saving be shown to the consumers so as to get insight in their consumption data and drive them to save energy?* Initially the theory describing the procedure of modelling choice experiment is explained. Following this, the setting up of stated preference experiment in context of the research which focuses on reducing energy consumption in office buildings using smart meter is described. And lastly, some details of the models that are used in analyzing the result are explained.

3.3.1 Setting up the choice experiment

In order to motivate households and employees working in office environments to reduce energy consumption, enormous studies has been experimented with various approaches so as to realize valuable results in this process. However, selecting a suitable and right approach is an essential factor to realize the valuable outcome. This study aims to find out the important characteristics that can have impact on the behavioral intention of the employees in office buildings to save energy using their consumption data generated by smart meters. Hence, it is very crucial to figure out what preferences of employees are toward different information characteristics and behavioral change factors while working in an office environment.

In this study stated preference (SP) is used over revealed preference (RP). SP and RP differs from each other on the ground of situations the choices are made at. RP usually takes place when the choice in study is made in real-life situation and on the contrary SP takes place when the choice is determined in controlled hypothetical environment. The advantageous nature of SP lies in selection of the attributes with different levels intended for the controlled situation and thus gathering data ultimately which is not possible with RP approach (Hensher D. A., 2005). With the help of stated choice, the collection of information based on complex and rare situations is possible, analyzing which its application in the real world can be realized.

In order to determine the participants to make a choice, the main challenge lies in identifying, understanding and using as much as information that an individual can consider in a process of realizing situation that can lead to choice determination (Hensher D. A., 2005). Energy reduction behavioral is not that is inherited in everyone, therefore the importance of researching is such areas lies in determining what can stimulate the preference of whole population of individuals to realize energy saving. individuals often execute their choice behavior after evaluating the physical, social, functional and economical aspects of the attributes presented to them. This stated choice approach can thus help in identifying which factors or attributes can prove to be important to have impactful impression on all people. Additionally, the unique feature of SP approach which enables the participants to select only the choice variable expressing their evaluation of all the attributes presented to them in a certain situation helps in handling the data and computing the results very easily.

Hensher (2005) provides a layout of eight stages that a researcher should follow so as to realize a stated choice experiment comprising meaningful and valuable choice alternatives and sets which can thus result into generation of useful data and results. Figure 12 shows the complete layout of all these stages involved in the procedure. The next few paragraphs illustrates the use of these stages in constructing choice experiment.

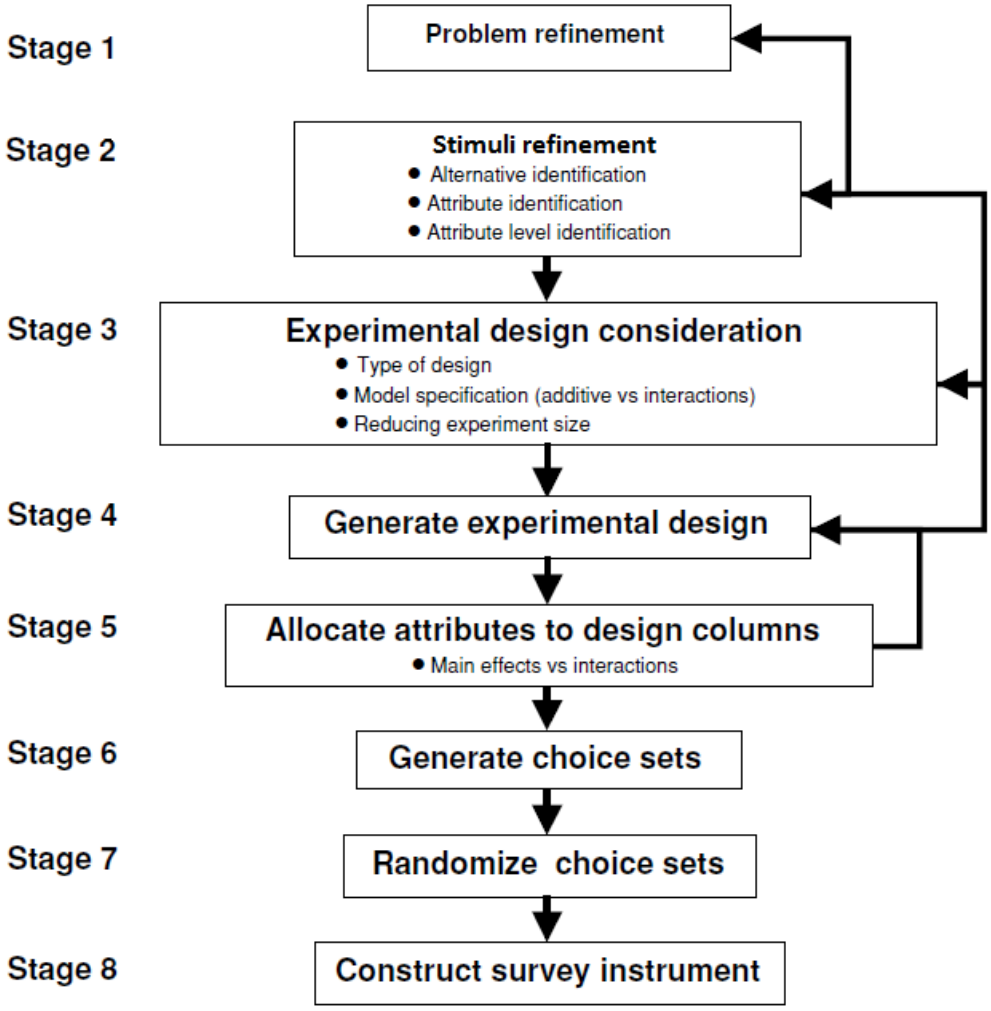


Figure 12 Experimental Design Process (Hensher D. A., 2005)

Problem refinement

The very first step included in the process to generate choice experiment is the problem refinement. This implies that the clear purpose for which experiment is carried out should be outlined before setting up experiment so that it is unambiguous what results need to be achieved at the end of study. As aforementioned, this research is carried out to analyze which attributes or factors can influence the behavioral intention of employees in office building in motivating them to save energy. it is also highlighted that the attention will be given to information characteristics, social interaction and gamification to attain the solution to the problem.

Stimuli refinement

A choice experiment provides the respondents with different alternatives to select from. These alternatives specification varies from study to study. For instance the study focusing on choosing bus or car for the attributes presented in the choice set considers selection of either of the labeled alternatives (bus or car). On the other hand, the study that considers the alternatives with different level of attributes and asks respondents to determine the most influential alternative are unlabeled ones and does not specifically has to be two, can be more as well and can also consists of option none of these. However, the number of alternatives in each choice set should be determined carefully by the researcher to avoid excessive alternatives option creating confusion and time consuming for the

respondent. Therefore the researchers should take care about the practical considerations of the study. Since this study focuses on identifying alternative that can motivate to save energy, three alternatives are used and are kept unlabeled. The third choice option none of these is introduced because there might be some attribute levels that target group feel unimportant to save energy, in such case none of them help them to give deviate from choosing any of the two alternative.

The following step consists of refining attributes and levels within it. Every alternative presents respondents with attributes to make a choice which they consider appealing. These attributes has the push and pull nature which determines why the target group intends to select one of the alternative depending upon their inclination towards the content of these attributes. Therefore in this case the attributes that can prove to have significant impact on determining their motivation to save energy should be identified. In order to realize stimuli input for the model, attributes those were identified as important during the literature study should be used. However, the limitation on the number of attributes and levels within each attribute should also be determined since it is very important to keep the choice set manageable for the respondents to give their response within a time frame reserved by them to fill in the survey. Therefore the attributes and their level that are relevant for study and interesting for the target group are considered in the choice experiment.

Subsequently, attribute levels are the levels that are assigned to each of the attribute considering the experimental design process. However, the number of levels for each attribute should be decided initially noting that the levels in each attribute does not have to be same in number. Hensher (2005) states each possible level in an attribute can be mapped to a point in utility space, more the levels we compute for an attribute, more the information we can analyze in utility space.

Experimental design consideration

Once the researcher has identified the above mentioned elements, the next step in the procedure is experimental design consideration. In this step the researcher has to choose which type of design he/she wants to consider and the model to use. Therefore the decision regarding whether to use full factorial design or not, whether to present the alternatives with labels or not, also the decision regarding reducing the number of levels in any attribute can be determined here. Along with this the reduction of the experiment size should also be considered since the possibilities to reduce the complete treatment design to fractional treatment design essential for experiment always underlies.

Generate experimental design

After all the characteristics to be used in the experiment are identified and the design strategy is adopted, the following stage is to generate the experiment. Therefore, the design columns are generated by allocating the attributes to these columns based on the combination of the attribute levels. In order to realize this the attributes levels need to be coded using the orthogonal codes. This consequently brings end to an design process and afterwards using guidelines given by Hahn & Shapiro (1966) choice sets are randomized so that they result into random selection and are now completed to receive the reliable data from the participants. As soon as the choice sets are realized, the complete survey is constructed and presented to the respondents.

Constructing a precise survey is very important since the researcher has to relate with the respondents so as make sure the content in the questionnaire is understandable. And special

emphasis should be given on this procedure since the results of this survey will generate the answers of the questions researched in this study.

Once the data from the desired number of respondents is received, the next step consists of analyzing in the NLogit software. However, there are still some data that is not reliable or is incorrect. Therefore such data has to be removed from the analysis. After the completion of all these steps, the data that can deliver the information about the preferences of respondents behavioral intention to save energy for the attributes presented in study can be identified and the relative importance of these attributes in realizing their motivation to save energy can be then quantified. The results thus obtained from this research can then be used by the management of office organizations, companies developing energy saving applications, organizations initiating energy saving program and even the energy supplier to develop an energy saving program for he employees in office building in order to motivate them to save energy.

3.3.2 Stated choice experiment

The survey for this study using stated choice experiment approach has focus only on the employees who has workstation in an office environment as the research problem clearly defines the intervention to change behavioral intention of employees in an office buildings using their consumption information available through smart meters. Consequently, to understand the characteristics of the participants in this study, as mentioned earlier, the socio-demographic questions asking personal and energy saving related questions are included in the survey in addition to the stated choice experiment. As this study does not focus on any particular country or geographical region, the language used to form questionnaire is English since it is understandable almost throughout the world.

Also following the findings from literature, the energy consumption of the employees in buildings level consists of huge amount of information. Therefore, the correct apportioning of this energy consumption on which level should be made to motivate employees in saving energy is optimized. Realizing that the information can be provided on individual level and group level, the potentiality on giving feedback on group level can induce the social-interaction factors within employees. Especially social control and cooperation, and instrumentality and self-efficacy (the feeling of your own action makes a difference). And observing the context of the research, data distribution on group level is implemented in the survey.

The study is made case-specific by describing the situation in the questionnaire so that the respondents put themselves in the mentioned hypothetical situation and realize their preference for the attributes used in choice sets. The underline case to be assumed mentioned in the survey is as follows :

"Assume that the management of your office has undertaken energy saving program, for which the employees in your office are divided into several groups. The division of groups is based either upon the number of employees (8-15) in each group or by forming a group of employees on each floor, depending upon the size and composition of employees. For this energy saving program, 'Smart meter' is attached so as to get information regarding energy usage of every group."

Subsequently, as the employees behavioral intention to save energy by giving them feedback on their energy consumption data using various influential attributes is the main aim of this study,

consideration of how this information should be explained to them when they participate in the choice experiment is chalked out earlier in the description section of the questionnaire. The respondents are shown the description in addition to the visuals of different attributes that they can see on the display screens. These visuals and the description of information are elaborated further in the influential attribute section. Also, to ensure that respondents can understand the information provided in description section, a test with pilot is conducted.

As stated by Klojgaard et al. (2012), who validated the implication of complete process of qualitative analysis using discrete choice experiment and essential steps to consider during this process, in order to realize genuine validation of the experiment, the attributes used for the choice experiment should be considered carefully with attention to inclusion of most noteworthy attributes that the respondents can easily relate with. All the attributes intended for the study are bundled in a set and presented to the respondents in a clear and concise manner to make trade-offs between the attributes. In a choice experiment, the motivation of the respondents is influenced by their characteristics, therefore special attention should be given to assure this relation. Additionally, the evaluation depends upon the levels of these attributes that changes with every choice set they encounter. Therefore, to ensure inclination of respondents to take tradeoffs, the levels of the attributes have to be determined carefully.

3.4 Setting up the experiment

3.4.1 Influential attributes

Intervention in the field of energy conservation is an complex process since various factors that can influence individual's behavioral intention needs to be identified considering the characteristics of the individuals. These factors can range from pro-environmental behavior such as social interaction, self-efficacy, social control and co-operation etc. to the characteristics of the feedback provided itself. With the potentiality of smart meter to generate the energy consumption data of the employees, this study focuses on determining behavioral intention to save energy in an office setting. Therefore, the attributes that can influence this motivation are carefully identified. The selection of these attributes that are included in the stated choice experiment, are based on the most important features that needs to be studied. From the extensive literature review of the previously executed research based on implementing energy saving program in different settings to realize change in behavior to save energy, the attributes that are related to this study are optimized.

Numerous studies has been carried out considering the characteristic of the information and their impact on energy saving behavior. Information characteristics such as **feedback type** and **feedback period** i.e. period for which the feedback is provided has been identified by the research to bring significant change in the behavioral intention determine different energy saving potential (Dario Bonino, 2012; Rob van Gerwen, 2010; Karen Ehrhardt-Martinez, 2010; Wokje Abrahamse L. S., 2011). Both of these features of feedback are identifed as direct feedback and indirect feedback by the literature, empahsizing on direct feedback to ensure energy saving more than indirect feedback. In this research both these categories are used in the choice experiment so as to determine the preference of participants on these categories and validate from the literature.

Following this, the pro-environmental behavior that can bring about inclination in the employees' intention for energy saving are identified though the literature. Normative **comparison** has been considered as an instrument that can encourage specific motives for energy consumption such as,

ambition and competition. When a comparison of consumer's own consumption to that of others is done, their own position in the surrounding is informed to them which advance their knowledge (FIischer, 2008). Hence customer informedness may relate to normative comparison. Using comparison various research has been executed in both residential and non-residential sector. Therefore, observing its potentiality in influencing behavioral intention of employees in office environment, it is considered as influential attribute for the choice experiment (Sam C. Staddona, 2016; Dixon, 2015; Kamilaris, 2015; Siero, 1996). From the literature comparison is can create energy saving potential depending upon the individual or group of people with whom the comparison is made with. Therefore, this attribute is used in the research to determine which group of people, the participants wants to compare with for the energy saving program to be effective.

Following this gamification elements are **goal setting** and **comparison** are included as attributes to study the effect of game elements on energy saving. It is often observed that during the energy saving program, participants are less motivated at the end of program compared to the initial stage, therefore literature argues that in order to realize energy saving throughout the duration of energy saving program and even later, it is necessary to engage employees in easy, fun and personalized programs with the added benefits of social and psychological motivations (Karen Ehrhardt-Martinez, 2010; Byron Reeves J. J., 2012). Through extensive literature review goal setting and competition is incorporated in this study. Various studies has been carried out using goal setting in energy saving (Sam C. Staddona, 2016; Nilsson, 2015; Owen, 2010; MCCALLEY, 2002). Literature links goal setting with self-efficacy, self-evaluative mechanism meaning these self-processes jointly regulate effort under condition permitting cognitive comparison between the standard and knowledge of performance (Bandura, 1983). Using these mechanism the employees in an office environment would perform in the direction of goal and the eagerness to achieve this goal would result into motivational effect. Literature relates goal setting with incentivisation in the form of social and monetary rewards and even if no rewards are considered it is still the form of giving incentive. For this research goal setting is considered with no benefits equivalent to rewards but the motivation to save energy.

Competition is another such mechanism that can induce energy saving motivation through the provision of the rewards. Various studies focuses on competition as game element that can determine the sense of competing with others with the benefits of rewards ultimately resulting into energy saving (Metzger, 2011; Handgraaf, 2013; Kuntz, 2012; Orland, 2014; Petersen, 2007) (Gardner, Environmental problems and human behavior, 2015) can create For the competition, rewards is considered in this research in the form of receiving points and rank which would ultimately lead to getting an reward. However, what type of reward would be given is not researched since this study only focuses on whether giving reward influences the behavioral intention of employees to save energy through competition. This decision of using the features of receiving points and rank is traced down from the literature.

Lastly, the attribute the **information screen** is used in the research which is termed as Persuasion meaning inducing positive or negative feelings or stimulate actions using the communications for example provision of information through the use of graphs, tables, images, encouraging text, interactive displays on either printed or electronic material (Staddona, 2016). Consideration of information screen in this research is regarding electronic screen that will show the employees all

the above mentioned attributes to stimulate their action. However, literature emphasizes on the importance of using communication as persuasion, but this research further investigates which type of display the participants prefer so that they generate motivation to save energy is discussed in detail in the following section.

Attributes	Levels		Explanation
Feedback type	1)	Appliance level information	Receiving energy consumption of every appliance used by group
	2)	Overall information	Receiving energy consumption information of all the appliances used by group together
Feedback period	1)	Daily	Receiving energy consumption information daily
	2)	Weekly	Receiving energy consumption information weekly
	3)	Monthly	Receiving energy consumption information monthly
	4)	Real time	Receiving energy consumption information every minute
Comparison	1)	Teams within office	Comparing energy consumption information with groups inside office
	2)	Teams outside office	Comparing energy consumption information with groups outside office
	3)	Company's average	Comparing energy consumption information with average consumption of all the groups
Information screen	1)	Public screens	Receiving energy consumption information on displays in public area
	2)	Personal screens	Receiving energy consumption information on own desktops
Goal setting	1)	Yes	Receiving target to reduce consumption
	2)	No	Not receiving target
Competition	1)	Yes	Receiving credits when target is achieved, leading to reward
	2)	No	Not receiving credits and reward

Table 1 Attributes and their levels used in choice experiment

3.4.2 Attribute levels and presentation

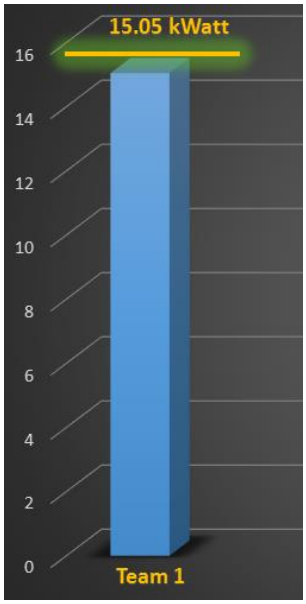
In this section various levels of the above discussed attributes are described along with the visuals they are presented to the respondents. however, initially the intention of this research was to present the alternative in choice set in the image form consisting of various levels of all the attributes included in the study. However, each respondent will receive 8 choice sets and each choice set having two alternative in display form would create enormous efforts for the participants to understand each alternative and select the motivating option. Moreover, the chances of losing interest in the questionnaire also underlie, therefore the decision to involve visuals displays in questionnaire was revoked and instead the respondents were provided with the description of all the attributes and their levels with the visuals prior to the start of choice experiment and the choice experiment included only the labels of attributes and levels within them.

Feedback type

The level of attributes for the attribute feedback are:
Level 1 : Appliance level information
Level 2 : Overall information (Premise or Building level data used by their group or floor)

Appliance level data exhibits the information regarding energy consumption of each and every appliance used by their group and the overall data implies net energy consumption of all the appliance used by the employees belonging to the particular group. Literature argues that overall information has lower energy saving potential (9%) as compared to appliance level information (12%). However, appliance level information gives insight in how much energy each and every appliance use, but this information can be excessive for the individual especially when working in office environment leading to distraction from their work. Therefore, considering the difference in the preference of different individuals, these levels are incorporated in the experiment.

To make respondents aware of how different feedback type look like if they are considered in the energy saving program and make them understand the importance of these levels the visuals are shown to them in the description section of questionnaire as shown in figure 13 and 14.



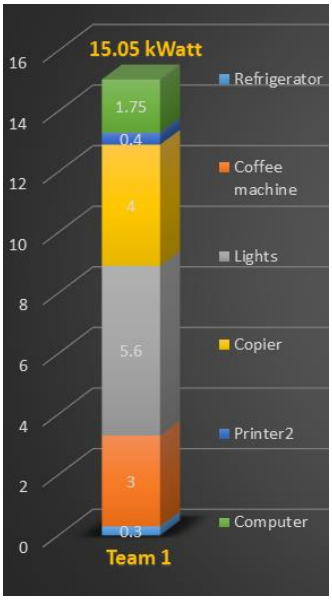


Figure 13 Overall information *Figure 14 Appliance level information*

Feedback period

The levels for attribute feedback period are:
Level 1 : Daily
Level 2: Weekly
Level 3 : Monthly
Level 4 : Real time

Real time feedback is considered as direct feedback and has the highest energy saving potential (12%) when compared to other feedback periods. Various studies has been carried out considering these different period of feedback, however significant result stating real time feedback can ensure more energy saving are not completely evident. Moreover, the frequency at which the feedback information is provided plays a key role in realizing energy saving in office environment. For instance feedback provided on monthly basis can detach employees from the energy saving program because of the static information for a period of complete month and on the other hand receiving information in real time i.e. every minute can be very stressful in the environment as aforementioned which can either distract them from work or from the energy saving program. Therefore the correct identification of the feedback period needs to be optimized. Hence all the levels from real time to monthly feedback are incorporated in the study. The combination of the real time feedback with appliance level data and the combination of weekly data with overall information is shown to respondents in the description to make them understand how the different feedback differs. However, in the choice experiment the effect of the attributes are considered as independent, but the relation of the different attributes used in the study is made for the purpose of visualization in the hypothetical surrounding. The visuals describing feedback period are shown in figure 15 and 16.

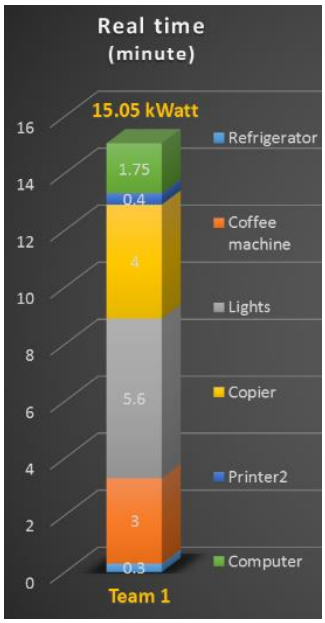


Figure 15 Real time appliance level feedback

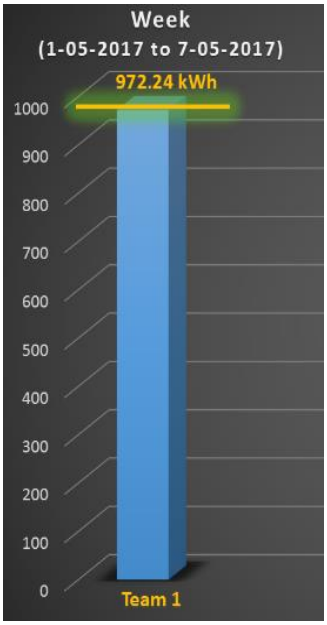


Figure 16 Weekly overall feedback

Comparison

The levels for the attribute comparison are:
Level 1 : Teams within office
Level 2 : Teams outside office
Level 3 : Company's average

For the attribute comparison levels comparison with teams within office, with teams outside office and company's average are considered. All these levels are considered as the normative comparison I literature and determines the principle of social comparison driving the behavioral intention in the direction of saving energy. comparison with other teams can induce the sense of outperforming others for the individuals with competitive traits, whereas for the individuals with self-efficacy behavior i.e. who does not need any competition to realize behavior change for the own wellbeing can consider company's average as an instrument to save energy. Moreover, comparison with the colleagues in own office can have different impact than the comparison with teams outside office as the individuals can feel more competition to outperform with the other offices that are already in the competition with the regards to their work, economy, position and image. Adding this competition for energy saving can increase the competition among them in order to outperform each other and thus ultimately leading to energy saving. Comparison with the groups within office premises and with office's average consumption has been undertaken by various researches, but the impact on energy saving by comparing with teams outside office has not been focused on a broader scale. Moreover a in a research by Staddona (2016), it is mentioned that the respondents gave the suggestion of comparing with teams outside their office would have been more effective. With all these considerations, the aforementioned three levels are included in the study.

The images shown in figure 17, 18 and 19 are described to the respondent to realize how these different levels are visualized.

Figure 17 Monthly overall comparison with company's average energy consumption

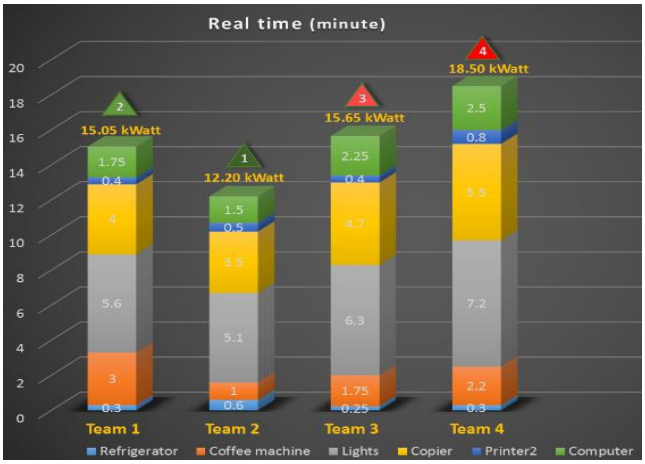


Figure 18 Real time appliance level comparison with teams inside office

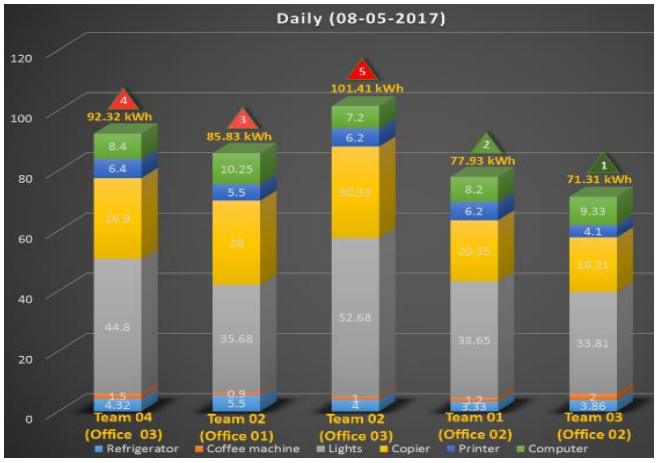


Figure 19 Daily appliance level comparison with teams outside office

Gamification elements

Gamification elements are gaining popularity in the field of environmental and energy research because of its potentiality in engaging the participants until the complete process of intervention with the features determining easy, fun and personalized programs with the added benefits of social and psychological motivations. Using the game elements in research, the importance of including game elements in tailored energy saving program using smart meters is realized from the insight in participants consideration for game elements to be effective in energy saving. Therefore, two attributes namely goal setting and competition that are used enormously in various researches are identified.

Goal setting

The levels for attribute goal setting are:
Level 1 : Yes
Level 2 : No

Goal setting for this research is considered as the goal provided to group based on their current energy consumption and with the motive of improving their performance so as to outperform other teams. Only two levels are mentioned in this attribute namely yes if the respondents want goal setting and no if they don't want goal setting. Goal setting enables the groups of employees in an office environment to perform in the direction of goal and the eagerness to achieve this goal would result into motivational effect to save energy. Moreover, literature states that goal setting to have self-efficacy and self-evaluative mechanism which would be interesting to observe from the respondents preferences of this attribute. Additionally, goal setting can be combined with providing reward for achieving goal but for this research no such rewards are linked with goal setting which will definitely recognize the self-efficacy characteristics of the participants. As goal setting varies from group to group, the respondents are described with the information that each team will receive different goals and realizing that one team is progressing towards their goal to achieve the target, the other teams will automatically start putting their efforts to attain their specific goal in order to outperform others. The visuals shown to the respondents to understand this attribute is illustrated in figure 20.

Figure 20 Goal setting

Competition

The levels for the attribute competition are:
Level 1 : Yes
Level 2 : No

Similar to goal setting, this attribute also consists of two levels yes for the respondents interested in it and no for them who are not interested in competing. As aforementioned, giving reward is not considered for the attribute goal setting, but it is considered for the attribute competition since without providing any form of reward the employees would not consider competition with other teams. However, in the description what the exact reward would be is not stated since the research focuses on identifying if competition can bring change in behavioral intention of employees to save energy and what kind of reward should be provided is out of boundaries determined for this research. The attribute competition is kept more or less similar to that of goal setting, but a significant feature of giving points if they achieve the target that would ultimately lead to receiving reward for the team with highest points is addressed. This specifically differentiate self-efficacy mechanism of goal setting with the competitive behavior of competition. Therefore to identify the effect of two different characteristics, attributes goal setting and competition are incorporated in this research under the title game elements.

The visualization to make respondents understand the feature of competition the image shown in figure 21 is visualized in the questionnaire.

Figure 21 Competition

Information screen

The levels for the attribute information screen are:
Level 1 : Public screen
Level 2 : Personal screen

Finally, depending on all the levels of the attributes the respondent prefer, the selected information would be shown on screens as a feedback. various researches focuses on different type of feedback option such as receiving information on printed boards, through email, on public displays etc. As this study focuses on initiating energy saving program using the above mentioned attributes from the data generated by smart meters, only digital displays are considered since the processed information based on above mentioned attributes can be directly feed to the digital display using applications. But the question arises that even if the digital displays are considered, whether the information should be provided on screens hanging in public area or every participant should receive the information on their respective screens using applications. But the display methods can have pro's and con's. For instance, providing information on personal screens can ensure easy access to information whenever needed, but at the same time gist of the energy saving program would be lost since the participants would no longer feel interested in social interaction which is possible if the information is showed on public displays. Therefore in order to check the validity of which screen the respondents choose to determine their behavioral intention in saving energy the two levels public screens and personal screens are involved in the study. Images in figure 22 and 23 are shown to respondents to assist them in visualizing the difference between two levels.

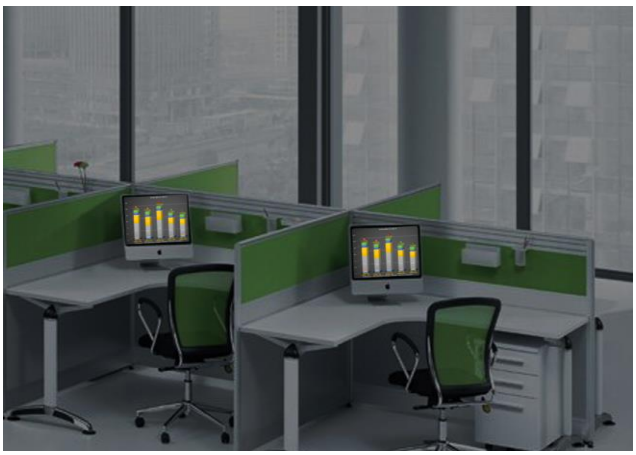


Figure 22 Personal screen

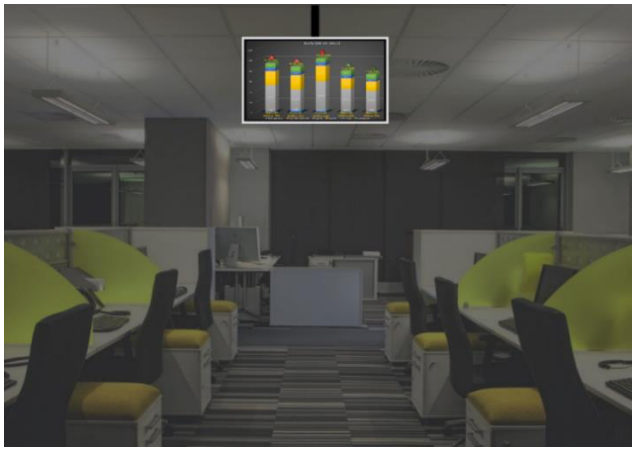


Figure 23 Public screen

3.4.3 Experimental design consideration

Now, after identifying all the attributes and their levels the next step for the researchers is to choose what kind of design is suitable to carry out experiment. The process of realizing the design for the discrete choice modelling is described on the following paragraphs and are based on the guidelines provided by Hensher, Rose and Greene (2005) in their book "Applied choice analysis: a primer".

The next step to construct the experiment is to select on whether to use full factorial design of fractional factorial design. In full factorial design all the possible combinations can be ensured, using the formula L^A where L are the number of attributes level and A are the number of attributes with L levels. The total number of influence attributes used in the choice experiment is 6, of which 3 consists

of 2 levels, 1 consists of 4 levels and 1 consists of 3 levels. This gives the total number of 96 treatments ($2^3 * 3^1 * 4^1$) for a full factorial design. Using a full factorial design would make it possible to estimate all possible main and interaction effects of attributes independent of each other. But while considering the inclusion of these many profiles, practical implication should be considered since it can be difficult for the respondent to handle them as the survey would be too long. The guidelines by Hahn & Shapiro (1966) provides the possibility of reducing this full factorial consideration to partial profile experiment with only a subset of the studied attribute. Therefore, the fractional factorial design is considered and the minimum number of treatment combinations useful of the choice experiment are computed using these guidelines.

Using these guidelines, depending upon the number of variables and their respective levels the fractional factorial design consisting of 16 treatment combinations is realized. This number of treatment combinations is relatively smaller than the full factorial design consideration consisting of 96 combinations. The basic rule of them for the number of treatment combination are, more the number of variables to be estimated, more is the number of treatment combinations required.

Further, decision regarding whether to use label for the experiment or not needs to be considered. Since this research is intended to select the alternative using the aforementioned attributes that influences the motivation of the respondents to save energy, no specific identification of the alternative is needed. Therefore for this experiment unlabeled design is chosen as the use of all possible alternatives to determine choice is considered.

3.4.4 Generated experimental design

To generate an orthogonal uncorrelated design, 16 treatment combinations are sufficient. Hahn & Shapiro (1966) provides a master plan to create a design matrix based on design consideration. The plan provides a precise and practical design matrix based upon the number of attribute and their respective levels. Table 2 provides the complete design along with the attributes labeling.

Design matrix						
Treatment combination	Feedback type	Feedback period	Comparison	Goal setting	Competition	Information screen
1	0	0	0	0	0	0
2	0	1	1	1	1	0
3	0	2	0	0	1	1
4	0	1	1	1	0	1
5	1	0	1	0	1	1
6	1	1	0	1	0	1
7	1	2	1	0	0	0
8	1	1	0	1	1	0
9	2	0	1	1	0	1
10	2	1	0	0	1	1
11	2	2	1	1	1	0
12	2	1	0	0	0	0
13	3	0	0	1	1	0
14	3	1	1	0	0	0

15	3	2	0	1	0	1
16	3	1	1	0	1	1

Table 2 Design matrix

3.4.5 Choice sets

From the generated experimental design, choice sets consisting various different treatment combinations are realized. These choice sets presents the alternatives made of selected attribute and their levels. Each respondent has to choose one alternative in every choice set which he/she prefers most influential in determining behavioral intention to save energy. The provision of option none of these is also made so that if they does not feel any of the alternative motivating they can select this third choice variable. As generated by fractional factorial design, total of 16 treatment combinations are used in the research which are presented as 8 choice sets with 2 alternatives each. In order to construct these choice sets, using Microsoft excel various treatment combinations are randomized manually over the choice sets. When the respondents face the choice sets, preferably each of them will randomly face all 16 combinations presented in 8 choice sets with 2 alternatives each. In order to realize their preference for energy saving, each of the alternative will act as an autonomous hypothetical situation consisting of the fixed influential attributes and their levels considered in that alternative. Once all the choice sets are generated the alternatives in each choice set are given name as "Option A", "Option B" and "None of these". An example of the alternative presented to respondents is shown in table 3.

Factor group	Attributes	Option A	Option B	None of these
Information characteristics	**Feedback type**	Appliance level information	Overall information	
	Feedback period	Real time	Weekly	
Social Interaction	**Comparison**	Teams within office	Teams within office	
	Information screen	Public screens	Personal screens	
Game elements	**Goal setting**	No	No	
	Competition	Yes	No	
Your choice		O	O	O

Table 3 Example of choice set in questionnaire

3.4.6 Questionnaire sample size

In order to decide the number of participants required for the choice experiment, Orme (1998) provides the guideline on how to estimate that.

The proposed equation is as follows:

$$N \geq 500 * \frac{L_{max}}{J * S} \qquad \text{Equation (3.1)}$$

Where,
N is the required sample size
L_{max} is the largest number of level for any of the attribute
J is the number of alternative included in the choice experiment
S is the number of choice sets that are presented to each respondent

Therefore, for this choice experiment largest number of level $L_{max} = 4$, the number of alternatives presented to respondents J=2, number of choice sets presented to each respondent S=8, which brings to the total sample size required for this study N=125 respondents.

3.4.7 Questionnaire design

In order to conduct a survey with the intention to find the answers to the research questions and hypothesis, a questionnaire is designed in English, since this study is carried out on a global level and of all the languages English is the most recognized language. All the people working in office environment were the part of this survey. On the guidelines mentioned above, the questionnaire is constructed using the Berg Enquete System, specially designed for the students of Built Environment studying in University of Eindhoven. Firstly the respondents were explained the purpose of study.

Following introduction, the survey consists of three main sections, with each section having certain purpose of collecting data regarding different aspects. More specifically, first section comprises of questions regarding the ecological and energy concern of the respondents. This will provide the information of regarding the behavioral, psychology and attitude of respondents towards energy conservation issue. From this section, the respondents inclination towards behavior intention to save energy would be analyzed and the validation of hypothesis outlined in section 2.10.3 would be examined. The second section consists of choice experiment where respondents will indicate their preferences for the presented choice sets. The third section has two parts; first part will present them questions regarding the importance of different attributes presented in the choice experiment. This will help in analyzing if there is difference between their preference for the attributes when combined in alternatives in choice sets and when asked separately. The second part consists of questions regarding their personal information, which will provide the information regarding socio-demographics characteristics of the respondents. Combining socio-demographics with the energy saving related questions in section 1 will assist to test the hypothesis. Detail questionnaire presented to respondent is depicted in appendix 1.

The first section includes questions related to energy and ecological concern, in which respondents are asked to provide information about their general energy saving behavior and opinion. All the respondents were asked to give the answer based upon 5 point Likert scale. All the questions that are asked are presented below, while the possible levels of answers is given in appendix 1.

1. *Are you aware of energy saving in private environment?*

2. *Do you regularly discuss with others opportunities to save energy?*

3. *"If everyone tries to save energy at offices, this will not make a difference to the total energy consumption for the whole city".*

4. *Do you perform regular activities at home with the concern towards energy saving?*

5. *Do you perform activities at office with the concern towards energy saving?*

Along with this, the questions regarding their exposure to smart meter and energy saving programs is asked. This will help in separating the participants who has experience of energy saving program with the unexperienced ones as the opinion of people who has exposure to the similar approaches this study is intended for can have preferences different than those who are not experienced. The questions are listed below and the answer options included in both the questions is yes and no.

6. *Does the management of your office has ever undertaken any energy saving program?*

7. *Have you ever heard about "Smart Meter", that can provide you detailed information about your energy usage?*

The next section consists of the choice experiment where respondents are invited to evaluate choice situations. First of all the respondents were asked to consider a case-specific assumption describing the situation as aforementioned, so that the respondents put themselves in the mentioned hypothetical situation and realize their preference for the attributes used in choice sets. Following this the description of the attribute and their levels with the visuals determining how they appear in hypothetical situation as mentioned in section 3.4.2 is explained. Subsequently, combining different attributes and attribute levels various profiles are constructed. At the beginning of choice experiment, each respondent is introduced with an example of how a particular choice set looks like.

Afterwards, each respondent is presented with 8 choice sets determined randomly by the software. Each choice set has three choice options to select from that motivates their behavioral intention to save energy in office environment. The first two choice options consists of alternative combining different levels of the attributes each and respondents were asked to give the preference for the alternative in the choice set that motivates more to save energy. In this way each respondent completes one fractional factorial design. Additionally, third choice option “None of these” is introduced in case the respondent does not find any of the two choice alternative motivating. Because, forcing respondent to select only from the presented alternatives will most likely result into over estimation of results.

Following the choice experiment, respondents are presented with third and the last section which has two parts. The first part consists of questions regarding the importance of different attributes and levels in determining the intention to save energy. These questions are asked to analyze the differences in their preferences regarding attributes presented in choice set and asked separately. These questions are asked after choice set so that the respondents gets the complete understanding of different attributes and levels from choice experiment and they can easily indicate the preferences based on their understanding. Second part reflects the persona status of the respondents. They are asked to provide answers regarding their personal attributes in order to get an overview of the characteristics of the respondent group. The reason for asking these questions at the end is because of the fact that respondent’s focus on questionnaire is less at the end of questionnaire and they can easily respondent to this type of questions. The included questions are described below and their answer levels can be found in appendix A.

Part 1

1. *How important is it to know the electricity consumed by single appliances (in addition to the total electricity consumed)?*

2. *How important is it to know the electricity consumed in real time?*

3. *How important is it to know the electricity consumed per month?*

4. *How important is it to compare your team's electricity consumption to other similar teams or to the office's average?*

5. *How important is it to have a target level for electricity consumption (the goals is not to consume more)?*

6. *How important is it to be able to collect points for reducing energy consumption (the more point, the higher your social status and the chances to win reward)?*

Part 2

1. What is your gender?

2. What is your age group?

3. What is the highest level of your education?

4. Which of the following categories best describes your primarily area of employment (regardless of your actual position)?

5. Which geographical region you belong to?

6. Which geographical region you are currently working at?

3.5 Data analysis

In this section the methods that are used to analyze the gathered data from the respondents is explained along with its importance and usefulness in data analysis. The sections starts with explanation about using descriptive analysis for the data analysis followed by Multinomial Logit model, Effect coding, and models goodness of fit tests.

3.5.1 Descriptive analysis

Descriptive statistics is a term given to analysis of data that assists in describing, visualizing and summarizing the generate data in a meaningful way for instance in this case a typical behavior pattern of the respondents with regards to energy concern can emerge from the data. Therefore, it is considered as an effective way of presenting data which aims at transforming raw data into more understandable formats that can be easily and quickly interpreted. This transformation into understandable format can be realized by rearranging, filtering, and ordering the data. Additionally

manipulations are also considered if required. In the survey, the questions other than choice experiment asked to respondents were mainly in nominal scale. However, other scales such as ordinal, interval and ratio can also be used but it is not considered in the questionnaire since it is not required. As aforementioned, data can be visualized in various different formats, however in this study mostly tables determining the number and percentage of respondents for specific questions is used along with some bar diagrams wherever necessary. Computation od descriptive analysis is mainly done using the functions available from Microsoft Excel.

Questions asked in the survey are mostly using the five point Likert scale, which can generate lower amount of answers for any of the level within five points. Therefore with possibility of combining the levels and generating new three level scale which was previously five point scale, answering scale for questions is reduced to three levels during analysis wherever needed.

Descriptive analysis also gives the behavior pattern and insight in the individuals characteristics. This analysis can be thus beneficial for comparing with the findings from other related studies or general population characteristic. Therefore, whether the sample group can be compared to the population can thus be determined.

3.5.2 Multinomial logit model

Multinomial logistic regression is the widely used approach in the field of researches that focuses on estimating the utility of parameters in the state choice experiments. The use of Multinomial Logit Model (MNL) is used to analyze the findings for the second part of the survey which focuses on sated choice experiment. MNL regression techniques is use to analyze the relationship between a non-metric dependent variables usually labeled as choice variables and one or more metric or dichotomous independent variables.

MNL model can estimate two types of effect namely main effects and interaction effect. Main effect is estimated as an effect of one of the independent variable on the dependent variable. In other words in relation with this study, the main effect can be described as effect on the respondents preference of intention to save energy when going from one level of the attribute to the next level considering that the remaining variables does not change. Therefore, every independent variable included in the research has a possible main effect on the dependent variable. And the dependent variable used in the study is the choice variable which are labelled as Choice A, Choice B and None of these. On the other hand, interaction effect occurs when the effect of one variable on the dependent variable has an impact on the estimation of another variable forcing it to change.

Using Multinomial Logistic Regression comparison of multiple groups is computed through a combination of binary logistic regression. For this study classical MNL model is used for the data analysis and it is briefly explained in the following paragraphs.

MNL model is based on some assumed considerations which states each individual q associates a utility to each alternative i which can be classified into an observed part and unobserved part. Therefore, considering index q as the index of respondents ranging from 1,….,Q and index i as the index for the preference for alternative ranging from i = 1,…,I, each individual q associates an utility with each alternative i determining the preference for intention to save energy. The utility function with these assumed considerations is as follows:

$$U_{qi} = V_{qi} + \varepsilon_{qi} \quad \text{Equation (3.2)}$$

Where,

U_{qi} is the utility of alternative *i* of individual *q;*

V_{qi} is the structural utility, which is the observed part;

ε_{qi} is the unobservable part which is unknown and often treated as random.

For the choice experiment, it can be considered that each individual will carefully judge the alternative to certain value which determines its utility and on the basis of highest utility of the alternative that can provide the maximum benefit in form of energy saving for this study will be chosen by the respondent. MNL enables to determine prediction of probability that an individual will choose one alternative over the other that is given in the choice experiment. And the function that realized this probability is given below:

$$P_{qi} = Prob\,(V_{qi} + \varepsilon_{qi} > V_{qj} + \varepsilon_{qj}) \quad \text{Equation (3.3)}$$

$$P_{qi} = Prob\,(\varepsilon_{qj} < \varepsilon_{qi} + V_{qj} - V_{qj}) \quad \text{Equation (3.4)}$$

The utility representation for the model is determined with the equation given below:

$$V_{qi} = \sum \beta_n x_{qin} \quad \text{Equation (3.5)}$$

Where,

β_n is the parameter representing the weight of attribute *n*

x_{qin} is the score of an alternative *i* on attribute *n* for the individual *q*

This equations combined can be rewritten into finding the probability that an individual *q* chooses alternative *i* in Equation below (Train, 2003) (Sungyop Kim & Ulfarsson, 2008).

$$P_{qi} = \frac{e^{V_{qi}}}{\sum_j e^{V_{qj}}} \quad \text{Equation (3.6)}$$

3.5.3 Mix Logit (Random Parameter Logit)

As observed from the above illustrated description of multinomial logit model, its main advantage lies in its simplicity in terms of both estimation and interpretation of resulting choice probabilities and elasticity. On one hand MNL has the closed-from choice probabilities and a likelihood function that is globally concave. MNL estimation is thus straightforward using the Maximum Likelihood Estimator (MLE). On the other hand it has been recognized that MNL not only imposes constant competition across alternatives – as a consequence of the independence of irrelevant alternative (IIA) property, but also lacks the flexibility to allow for individual-specific preferences (Sarrias M. D.). With the advancement in technology, design of more powerful computers and the improvement in simulation-aided interface in the last decades, researchers are no longer restricted to use models with closed-form solutions that may lead to unrealistic behavioral specifications. In fact much of

recent works focuses on extending the MNL to allow for random-parameter models that accommodate unobserved preference heterogeneity.

Mix Logit Model (MIXL) is the most popular extension of the MNL model that allows the parameters to vary randomly over individuals by assuming some continuous heterogeneity distribution a priori while keeping the MNL assumption that the error term is independent and identically distributed. Flexibility in mix logit model lies in its ability to approximate any Random utility model and it does not exhibit the IIA property encountered in MNL. Furthermore, the parametric heterogeneity distribution can describes how preferences vary in the population (Hensher D. A., 2001).

Mix Logit model also referred as Random Parameter Logit model is somewhat similar to the random coefficient model of linear regression. Mix Logit is based on same assumptions of MNL that an individual (*q*= 1….Q) makes a choice amongst alternatives *I* in each of the choice situation *T*. it is assumed that the individual *q* will chose the alternative with highest utility considering the full set of offered alternatives in choice situation *T*. Therefore the relative utility associated with each alternative *i* as evaluated by individual q presented in a choice situation *t* is represented in the utility expression of the general form as shown in equation 3.7.

$$U_{qit} = \beta_q \mathrm{V}_{qit} + e_{qit} \qquad \text{Equation (3.7)}$$

Where,

U_{qit} is the utility of alternative *i* of individual *q;*

V_{qit} is the structural utility, which is the observed part;

β_q *and* e_{qit} is the unobservable part which is unknown and often treated as random. Within a logit context, the condition that e_{qit} is independent and identically distributed (iid) extreme value type 1 is imposed.

However, allowing the possibility that the relevant information to make a choice that is unobserved may be very important in reality and can induce correlation in each choice situation and also across all the choice situations. Therefore to take this into account a stochastic component i.e. unobserved part is partitioned into two uncorrelated part. One part is correlated over alternative and heteroskedastic and the other part is independently and identically distributed over alternatives and individuals as shown in

$$U_{qi} = \beta' x_{iq} + [\eta_{iq} + \varepsilon_{iq}] \qquad \text{Equation (3.8)}$$

Where,

η_{iq} is a random term with zero mean whose distribution over individuals and alternatives depends on parameters and observed data related to alternative i and individual q,

$\varepsilon_{iq}$is a random term with zero mean that is iid over alternatives and does not depend on parameters of data from individuals.

Mixed Logit models assumes a general distribution for η and an iid extreme value for ε. The general distribution can be normal, lognormal, triangular etc. Density of η is denoted by $f(\eta|\Omega)$ where Ω are the fixed parameters of the distribution. For a given value of η the conditional choice probability is logit since remaining error term is iid extreme value:

$$Li(\eta) = \frac{exp\,(\beta' x_i + \eta_i)}{\sum_j exp(\beta' x_j + \eta_j)}$$ Equation (3.9)

Since η is not given, the choice probability in this logit formula integrated over all values of η weighted by the density of η as shown in equation.

$$Pi = \int Li(\eta)\, f(\eta|\Omega) d\eta$$ Equation (3.10)

Models of this form are called mixed logit because the choice probability is a mixture of logits with f as the mixing distribution. Therefore, one way of making appropriate specification of f and also used in this study is known as random parameter specification, which involves specifying each β_q associated with an attribute of an alternative as having both a mean and a standard deviation i.e. it is treated as a random parameter instead of a fixed parameter.

3.5.4 Effect coding

In order to estimate the utility of each categorical attribute used in the choice experiment they need to be coded so as to realize comparison of them with each other. There are two techniques namely dummy and effect coding using which these variables can be coded and the non-linear effects among them can be analyzed. Both the techniques has the potential of measuring non-linear effects in the attributes levels. For this study effect coding is used since it has the advantage of directly interpreting the resulting values after coding. Also as suggested by Hensher, Rose, & Greene (2005), using dummy coding will result into perfect confound of the base level with the grand mean as well as each attribute dummy coded will also have confound with the grand mean which arises the question as to what have me measured? On the other hand in case of effect coding there is no perfect confounding of the base level with the grans mean of the utility function, therefore this coding strategy is used in this research as it can measures the effects straight away. The effect coding thus realized is illustrated in table 4. Effect coding for the base level or reference level for the attribute with two levels has coding -1, with three levels has -1 -1, and with four levels has -1 -1 -1.

Levels	**Two level** Indicator 1	Utility	**Three level** Indicator 1	Indic-ator 2	Utility	**Four level** Indicator 1	Indic-ator 2	Indic-ator 3	Utility
1	1	β_1	1	0	β_1	1	0	0	β_1
2	-1	$-\beta_1$	0	1	β_2	0	1	0	β_2
3			-1	-1	$-(\beta_1 + \beta_2)$	0	0	1	β_3
4						-1	-1	-1	$-(\beta_1 + \beta_2 + \beta_3)$
Parame-ter	β_1		β_1	B_2		β_1	β_2	β_3	

Table 4 Effect coding

3.5.4 Model goodness of fit test

This section discusses various approaches that can validate the quality of the estimated model and determine if the model is fit enough to interpret the results i.e. if the model fits the observed data. The approaches to execute these test are log likelihood ratio, log likelihood ratio statistics, R-square and Chi-square. All these methods are described in the following paragraphs respectively.

Log likelihood

In a typical stated choice experiment, the main objective of the researcher is to compute unknown parameters β. Log-likelihood (LL) is defined in such a way that it maximized the prediction obtained by the model. LL function are often used to estimate the model from choice experiment. Using NLogit software package MNL model computes the log likelihood function for the model to be estimated. However, it only calculates the LL values for constant only model and optimal model. In order to calculate the LL for the null model i.e. the model with all predictors set to zero, a manual computation is required . MNL considers that the choice observations are independent over all decision makers and choice situations presented in the experiment. Additionally, more the restrictions are added in the MNL model, lower is the LL. The equation that determines the log likelihood LL_{β} for the estimated model and equation 3.7 illustrates the LL_{0} formula.

$$LL(\beta) = \sum_{n=1}^{N} \sum_{i} y_{ni} \ln(P_{ni}) \qquad \text{Equation (3.11)}$$

Where,

LL(β) is the log likelihood of the proposed model with the estimated parameter of β;
N is the total sample size used in the model;
y_{ni} is the choice of one individual *n* made for an alternative *i* which can be 1 or 0;
P_{ni} is the probability of the individual *n* choosing alternative *i.*

$$LL(0) = \sum_{n=1}^{N} \sum_{i} \ln \frac{1}{j} \qquad \text{Equation (3.12)}$$

Where,

LL(0) is the log likelihood of the null model with all parameter of β=0;
N is the total sample size used in the model;
J is the total number of alternatives in choice-set *t* for individual *n.*

Log likelihood ratio statistics

Log likelihood ratio is the prominent way of testing the performance of the estimate model when compared with the null model. The mechanism behind log likelihood ratio is, it should improve with the addition of parameters in the model. In other words the estimated model should show significant improvement in the ratio when compared to the null model where all the parameters are set at zero. And this improvement decides if the model is good for interpreting results. Equation 3.9 by Train (2003) shows the calculation of log likelihood ratio.

$$D = -2\,(\,LL_0 - LL_\beta\,)$$ Equation (3.13)

Where,

D is the log likelihood ratio;
LL_0 is the null-model log likelihood, with all the parameter zero;
LL_β is the proposed model log likelihood, with the estimated parameters of β.

Additionally, depending upon the variables used in the model the degree of freedom is expressed using which the chi-square value can be recognized from the standard chi square table for assumed confidence range. Log likelihood ratio can be compared to this chi-squared value for the degree of freedom differences between the model. If the value of D exceeds that of chi-square value at a certain confidence interval then the assumption will be rejected. If the value of D is smaller than that of chi-square value then the estimated model is said to be not better than the base model. However, if the LL_0 is used to calculate the ratio for the same two alternative models, then the model with the higher ratio value can be considered as the model that best fits the data in it.

R-square

To calculate the R-square for the model that determines the goodness of fit, pseudo-R^2 statistics has to be estimated. The R-square form Mcfadden (1974) is used to validate the overall fit of the of a linear regression model. Equation 3.10 illustrates the calculation of pseudo-R^2.

$$R^2 = 1 - \frac{LL_{Estimated\ model}}{LL_{Base\ model}}$$ Equation (3.14)

Where,

R2 is the pseudo-R2, which shows the level of improvement over the null-model;
$LL_{Estimated\ model}$ is the null-model log likelihood, with all the parameter zero;
$LL_{Base\ model}$ is the proposed model log likelihood, with the estimated parameters of β.

When the estimated model performs exceptionally well i.e. when the sample's choice is perfectly predicted by the model, then the resultant likelihood function is equal to 1 which determines log likelihood function is o and resulting $R^2 = 1$. However, such ideal case scenario is next to impossible and therefore the discussion regarding which value is best for the likelihood ratio always arises. Usually it is considered that if the R^2 vale is between 0.2 and 0.4 then the model can be said to fit the data satisfactorily. However, the value lower than 0.1 is considered as week but in situation where human behavior and psychological actions are considered for the study then it is said to be lower since predicting human behavior is difficult.

4 Respondent preferences

In this section, the final results from the gathered data and the MNL models are presented. The section commences with the descriptive analysis followed by several MNL models.

4.1 Survey response

The online survey ran for about 10 days from 12th May until (and including) 22nd May. Since the energy saving concern is a global issue, the research and hence the survey is not limited to any specific country or region. Along with the energy saving concern the another aspect this research focuses on is the energy saving in office environment. Therefore to find the potential respondents having a workstation, the online survey has been spread worldwide. With the help of social networking sites and various channels the survey could reach the potential respondents:

- Using the social networking medium facebook close friends, colleagues and business contacts were approached to fill out the questionnaire.
- Linkedin enabled to send the questionnaire link to all the connections and this resulted in 1054 people viewing the post.
- Various Expats groups on facebook acted as another powerful source that helped in getting the respondents.
- The url of the online survey along with the short description were also circulated among the personal contacts using whatsapp. Also the extended description stating “forward this message to your friends and colleagues working in offices” was added while sending to the close friends and colleagues.
- Lastly, a contact from India who owns a medium-scale software company In India was approached to help gathering the respondents. The helped in getting the responses from the employees of this company.
- When the responses received were sufficient enough for the analysis to be carried out, the questionnaire url was deactivated.

Although the questionnaire reached enormous number of people, 696 respondents were attracted by this concern of energy saving in offices and they opened the url to fill out the survey. Out of this 696 respondents, 208 respondents completely finished the survey by filling out responses for all the questions asked and making choice for 8 choice sets presented to each.

After analyzing further the data, to realize If it is good for analysis, it was observed that some respondents did not take the questionnaire seriously and just marked all the responses same in choice experiment. Therefore, these respondents were removed from the data set and finally number of respondents with genuine responses reduced to 193. Therefore, the complete analysis is carried out considering 193 respondents.

Respondents	Started	Finished	Refined
#	696	208	193
%	100%	29.88%	27.72%

Table 5 Ratio of survey started Vs survey finished

4.2 Descriptive analysis

Once, the procedure of gathering the data finished, the data of the finished responses is extracted from the online survey system and some basic information is derived at the very first sight. Major difference in the number of men's and women's participation is observed. More men than women (66.83% vs 33.17%) participated in the online survey (table 6). 193 respondents who properly managed to finish the survey completely, were also able to provide the information regarding their socio-demographics characteristics and the questions asked can be found in the appendix B .

Gender	Male	Female
#	129	64
%	66.83%	33.17%

Table 6 Analysis of Men's and Women's participation in survey

Considering the fact that the research is based on the influencing employee's decision in office building, the smallest age category mentioned in the questionnaire was 18 to 24 since most of the people join offices as a full time or part time employees or intern between this age group. Majority of the respondents were between the age group 25-35 (64.24%). And only 8 respondents (4.16%) were above 45 years. Since the distribution of the respondents in different age categories showed a drastic difference, in order to further analyze the data meaningfully the categories are narrow down according to the number of respondents in each category. Table 7 illustrates the complete overview of the respondents participated with respect to their age category. And the detailed distribution of respondents with respect to age can be found in appendix B.

Sub age group	18-24	25-34	>35
#	47	124	22
%	24.35%	64.24%	11.41%

Table 7 Refined age groups into sub-groups for further analysis

Another characteristic considered in the socio-demographic is the education of respondents and their field of employment. Though the level of education laid in questionnaire ranged from the lowest (trade/technical/vocational training) to highest (doctorate degree), most of the respondents appeared to finish Bachelor (46.11%) and Master degree (42.48%). Here also the range from the lowest degree to the highest degree has a major difference in distribution of participants, this socio-demographic characteristic is further sub grouped into Bachelor's and lower and Master's and higher. This sub-division resulted into two categories with almost same respondents number as seen in table 8. And the detailed distribution of respondents with respect to level of education can be found in appendix B.

Education sub-group	Bachelor's and lower	Master's and higher
#	92	101
%	47.66%	52.34%

Table 8 Refined education levels into sub-groups for further analysis

Another socio-demographic characteristic mentioned in the survey is the geographical region the respondents belong to and the geographical region they are currently working at. Asia contributed to the highest number (80.31%) of respondents, following this is the European Union (13.47%) and United States (3.11%). On the other hand, while analyzing the respondents working area almost same pattern of distribution is observed with a slight variation. This particular socio-demographic characteristic also has the same pattern as seen for the previous characteristics. It is not feasible to consider all these areas for the analysis since the distribution of respondents for different area varies majorly. Hence, these geographical region are further sub divided into two categories namely western region and non-western region (table 9) where western countries comprises of all the region of America, European Union, United Kingdom and eastern countries consists of Asia, Middle East, Oceanic, The Caribbean and Africa. And the detailed distribution of respondents with respect to nationality and job location can be found in appendix B.

Geographical Region	Nationality (#)	Nationality (%)	Job location (#)	Job location (%)
Non-western region	158	81.86%	130	67.35%
Western region	35	18.14%	63	32.65%

Table 9 Refined geographical locations into sub-groups for further analysis

Lastly, as the scope of research being targeted to the employees working in offices, it is important to know the working sector of the respondents. Hence, the questionnaire also gave respondents the list of various possible working sector to select from. The data thus gathered showed various proportions of the respondents in different fields. Of them the major (22.80%) worked in the architecture sector, and following it software sector showed the second highest number (10.88%) of respondents.

Again, in order to consider this data for the analysis it is very important to sub-group it into meaningful categories for the further analysis. Therefore, the job profiles with more or less similar fields or with interdisciplinary fields are grouped together and the rest that has very low number of respondents are combined together with other category. As a result of this the profiles are sub-divided as built environment (architecture and construction); software, information and telecommunication; Education; and others as illustrated in table 10.

Job profile	#	%
Built Environment	62	32.12
Software, information and Telecommunication	38	19.69
Education	26	13.47

other	67	34.72

Table 10 Refining job profiles into sub-groups for further analysis

Along with socio-demographics, some questions in the survey asked the respondents to state the degree of their exposure towards energy saving concern. The questions asked are illustrated below:

The very first question asked at the start of survey is *"Are you aware of energy saving in private environment?"*. The literature strongly relates energy saving intention with the behavioral intention, hence it is very important to have insight in respondents concern regarding energy saving in their private settings i.e. their own houses. Because, individual's intention to save energy in office can be expected if he/she has concern for their own property. And almost half of them (50.77%) indicated that their awareness of saving energy in private environment is more than average.

Aware of Energy saving in private environment	Not at all aware	Slightly aware	Somewhat aware	Moderately aware	Extremely aware
#	8	33	54	73	25
%	4.15%	17.10%	27.98%	37.82%	12.95%

Table 11 Respondents distribution according to awareness for energy saving

Furthermore their frequency of discussing with others the opportunity to save energy was also asked. And around 75% of them have discussed the opportunities to save energy. Sometimes turned out to be the most preferred category which indicates that the respondents who participated in this survey put at least some efforts for energy saving.

Discussing opportunities to save energy	Never	Rarely	Sometimes	Often	Always
#	12	38	72	52	19
%	6.22%	19.69%	37.31%	26.94%	9.84%

Table 12 Respondents distribution according to frequency of discussing energy saving opportunities

Respondents were also asked to indicate the level at which they perform activities at home and offices with the energy saving concern. As expected, the respondents perform activities with energy concern more at home than at offices. Despite of this fact, the responses shows that both at office (80.83%) and home (92.23%) the activities with energy saving concern is performed more than rarely.

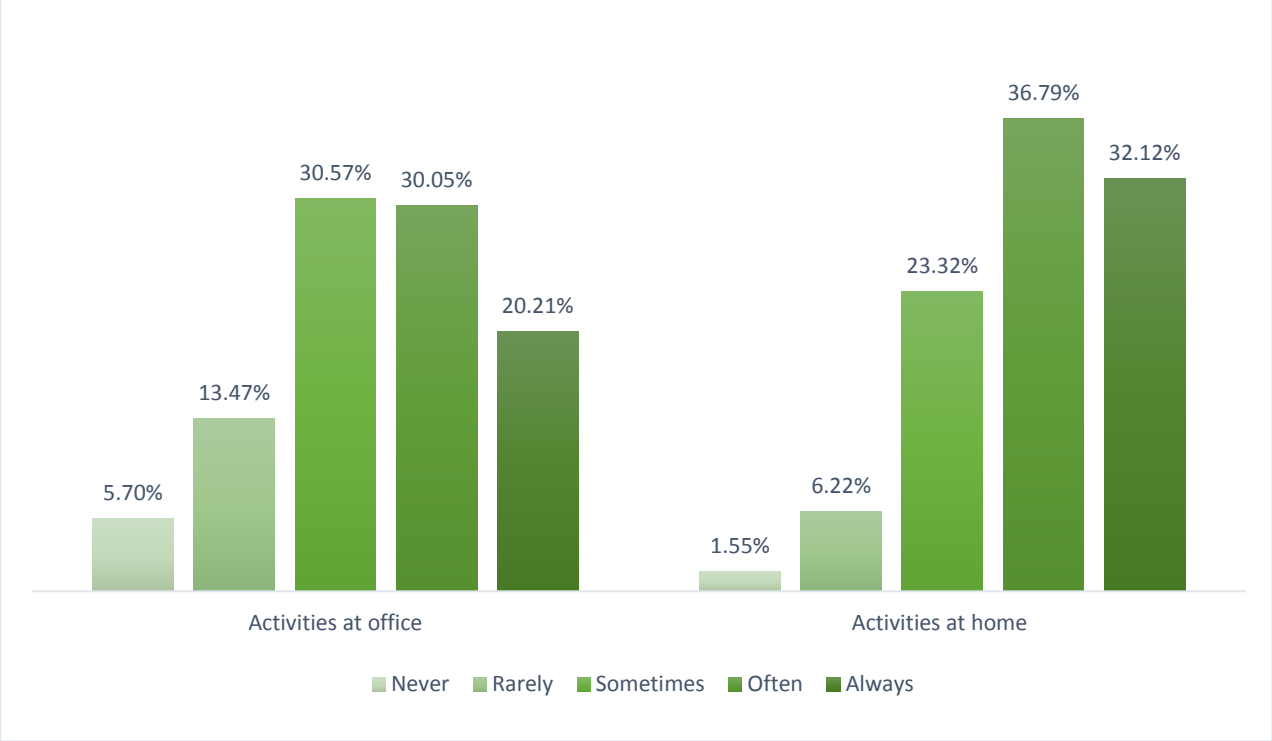


Figure 24 Respondents distribution according to performing activities at home and office with energy saving concern

In order to know, if the respondents have ever been exposed to Smart meter and also if the management of their company has ever undertaken any energy saving program (not specifically with Smart meter but more in general terms). The responses shows that around half of the respondents have participated in the energy saving program whereas only quarter of the respondents (24.87%) indicated their exposure to smart meters.

Answer	Smart meter (#)	Smart meter (%)	Energy saving program (#)	Energy saving program (%)
Yes	48	24.87%	89	46.11%
No	145	75.13%	104	53.89%

Table 13 Respondents distribution according to participation in energy saving program and awareness of smart meter

Lastly, the question regarding the importance of different variables in determining energy saving intention are asked. These variables are presented to respondents which are assumed to be the output of their energy consumption data as explained in choice experiment.

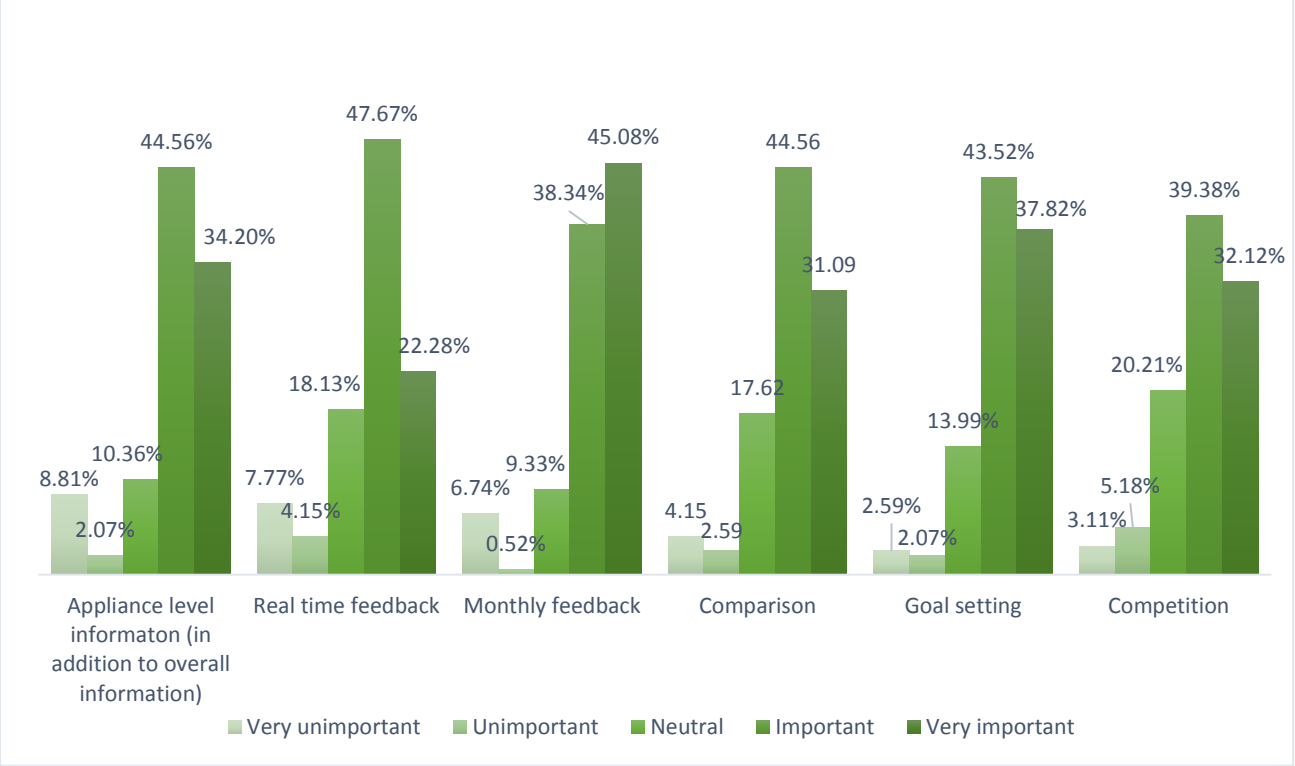


Figure 25 Respondents distribution according to importance of various attributes presented in choice experiment

Variables	Very unimportant		Unimportant		Neutral		Important		Very important	
	#	%	#	%	#	%	#	%	#	%
Appliance level information (in addition to overall information)	17	8.81%	4	2.07%	20	10.36%	86	**44.56%**	66	34.20%
Real time feedback	15	7.77%	8	4.15%	35	18.13%	92	**47.67%**	43	22.28%
Monthly feedback	13	6.74%	1	0.52%	18	9.33%	74	38.34%	87	**45.08%**
Comparison	8	4.15%	5	2.59%	34	17.62%	86	**44.56%**	60	31.09%
Goal setting	5	2.59%	4	2.07%	27	13.99%	84	**43.52%**	73	37.82%
Competition	6	3.11%	10	5.18%	39	20.21%	76	**39.38%**	62	32.12%

Table 14 Respondents distribution according to importance of various attributes presented in choice experiment

Majority of the people indicated all the variables mentioned above to be important in determining their intention to save energy. These variables will be crosschecked with the outcome of choice experiment so as to determine if they preferences are same or it changed when asked separately.

4.3 Model estimation and analysis

After the descriptive analysis, the data is then analyzed using NLogit software package. This software has various models that can estimate the significance of various attributes and can also determine the goodness of fit of model by estimating the R-square. Using MNL model from NLogit, the characteristics that influences the employee's intention to save energy in an office building is studied. Firstly the performance of the actual model is tested to validate the usefulness of the optimal model by comparing it with null and constant only model. After the validation of performance, the optimal model results are analyzed. Along with the optimal model some additional models considering comparison between different respondents groups are analyzed. These models that exhibits group specific comparison based on personal characteristics of respondents also explains the R-square value that determines how well the data fits the model.

4.3.1 Model goodness of fit

In order to test if the performance of model is satisfactorily to draw the findings from it, the log likelihood ratio is determined as shown in equation 3.13. Log likelihood ratio statistics provides the opportunity to test the performance of the attributes on the model using the collected discrete choice data. Comparison is made between the null model, the constant only model and the optimal model to determine the log likelihood ratio test. In the null model, the complete data is set to zero and the probability that any option among three given option is selected is given by dividing data equally (0.33) for all three options. In the constant only model, only the constant which represents one choice alternative is included. And the optimal model is the one with all the variables from survey included providing more context to the model and giving the most optimal likelihood.

Table 15 shows the log likelihood, the log likelihood ratio compared to the chi-square. The chi-square value can be obtained from the standard chi-square table by considering the degree of freedom difference compared to that of the null model generated by the NLogit model. The table shows that the log likelihood ratio is higher than that at minimum value at 10 degree of freedom at 90% confidence interval in the chi-square table that shows there is significant improvement in the model. Both constant only model and the optimal model are significantly better than the null model.

The calculation to obtain Log likelihood for null model is as follows:

Log likelihood of Null model = Number of Observations X Natural log (prob. of selecting each choice)

Number of choices in choice set is 3, therefore probability of selecting each choice is 0.33 and number of observations is 1544.

$$\text{Therefore, } \boldsymbol{LL_{null}} = \mathbf{1544 \ln (0.33)} = \mathbf{-1711.7751}$$

	Null model	Constant only model	Optimal model
Log likelihood	-1711.7751	-1388.5412	-1306.08533
Degrees of freedom	0	1	10
Chi square (probability = 0.1)		2.706	15.987
Log likelihood ratio	-	646.4678	811.37954

Table 15 Log likelihood ratio comparison with the chi-square

Following the log likelihood ratio statistics, the R-square of the model is calculated. Although NLogit software package computes the R-square for the model, but it can also be calculated using the equation 3.10. For the researches around any sector using discrete choice method, R-square provides with the information regarding the goodness of fit i.e. how good the model fits with the received data. Generally NLogit provides with R-square value as an output of comparison between the optimal model and the constant only model. However, in order to find the more optimal value of R-square, the optimal model can be compared to the null model using the earlier mentioned equation. For the R-square value to be optimum, it should be between 0.2 and 0.4. And the R-square value compared to the null model already shows the value of 0.2611 which shows that the model has a good fit with the data received. Although while comparing the R-square value with the constant only model the value is near to 0.1 indicating the goodness of fit is poor. This low R-square value may be the outcome of certain reasons that are explained in the next section, but this does not matter since the R-square value compare to the null model is already indicates a good fit.

	Compared to the constant only model	Compared to the Null model
(Pseudo) R-square	0.0594	0.2611
Adjusted R-square	0.0563	-

Table 16 R-square comparison

4.4 Multinomial Logit (MNL)

The data analyzed using the MNL model can be interpreted with the generated results given by the estimates β. The β-estimate illustrates the importance of a certain attribute level. if the β-estimate is higher, then the contribution towards the utility is higher. The model gives the β-estimate of different levels of any attribute by giving out the coefficients and level of significance. The model provides all the levels of any attribute except the last one with the β-estimate generated in NLogit. And the last level which is considered to be the base level is computed manually using the effect coding as explained earlier. So mathematically it is the sum of all the β-estimates level multiplied by -1. The total sum of β-estimate of all the levels is zero again.

Table 21 shows all the attributes of the choice sets for which the MNL model has computed the significant and non-significant effect on the behavioral intention of the respondents to save energy. The attributes with less than 90% of the statistical significant range are identified as non-significant

levels of the attributes and those with more than 90% are considered as the significant. The model output in form of β-estimate is also termed as the part worth utility.

After the analysis, the MNL model showed the goodness of fit of 0.0594. The model gets better when it reaches the value of 1 and the values between 0.2 to 0.4 indicates a good model. In this case the R-square value is relatively low and the reason behind this might be the purpose of this study which is related to changing human intention to save energy through behavioral change. The studies that takes human behavior into account has relatively lower goodness of fit because the human behavior is difficult to predict than say physical activity (Frost, 2013). And the survey for this study has various questions regarding the respondents exposure to energy saving measures and related attributes. Nevertheless, the value of R-square when compared to null model is still better (0.2611) and hence the model is considerable for the analysis. Table 17 illustrates the output from the MNL model and following that statically significant levels are studied. The MNL model also shows the impression of respondent on selecting one of the choice sets by giving value of constant. In this case the value for constant is positive and significant which shows that respondents has chosen one option among the alternatives and not the option none of these. This also indicates that the choice sets presented in the study proved to have positive impact on changing behavioral intention to save energy. Following the interpretations of output of optimal MNL model, some more models comparing different categories are illustrated.

Attributes		Attribute levels	Part-worth utility	Significance
Feedback type	1	Appliance level information	**0.12913**	***
	2	Overall information	**-0.12913**	***
Feedback period	1	Daily	-0.04305	-
	2	Weekly	0.07662	-
	3	Monthly	-0.09157	-
	4	Real time	0.05800	-
Comparison	1	Teams within office	**0.11982**	**
	2	Teams outside office	-0.07934	-
	3	Company's average	-0.04048	-
Information screen	1	Public screen	**0.14093**	***
	2	Personal screen	**-0.14093**	***
Goal setting	1	Yes	**0.24394**	***
	2	No	**-0.24394**	***
Competition	1	Yes	**0.37073**	***

	2	No	**-0.37073**	***
Constant choice A			**1.82110**	***
***1% **5% *10% significance				

Table 17 Studied attributes along with their β-estimate and level of significance

4.4.1 Interpretation

Feedback type

Feedback type has two levels namely appliance level data and overall data. Analysis shows that the appliance level data is significant. Moreover this level is positive means that this particular level has positive influence on one's choice. The coefficient for appliance level data is 0.12913 which is not very high as compared to other highest coefficients from other attributes. This shows that although appliance level data being one important parameter to motivate people in the offices to save energy, it does not seem to be the most important attribute in determining the intention to save energy. Although literature states that appliance level data is a direct feedback provided to the consumers and it can ensure energy saving of 12% (Ehrhardt-Martinez, 2010). But the respondents attraction towards other variables with the higher co-efficient such as game elements and feedback screen has the higher potential to determine energy saving intention since they are social psychological factors. And from this analysis it can be said that social psychological interaction based on information are more important to an individual than the characteristics of information itself.

Feedback period

Feedback period proved to be the least important attribute in determining the behavioral intention to save energy. None of the level being significant and all the β-estimates being lower than 0.1 (negatively or positively) shows that the variances in levels of this particular attribute in each alternative has not been considered by respondents in decision making. Moreover, period is temporal factor and realizing the information received during different time period would be tough for the respondents within the time frame they filled out the questionnaire. Hence, instead of understanding different feedback period and its importance, they must have answered considering the other factors that are more important and intuitive. And as mentioned earlier, this study also showed that people bend more towards social psychological factors than the feedback characteristics itself. Still in order to draw some conclusions based on the feedback period, the β-estimates of the levels real time and weekly are positive meaning these levels has positive influence on alternative selection and on the other hand daily and monthly had the negative impact on alternative selection. From the literature, real time is considered as the direct feedback and daily feedback is closely associated with it. Both the feedback period showed opposite co-efficient. On the other hand weekly and monthly feedback are associated with the indirect feedback and still they showed opposite behavior. This shows that the respondents lack of understanding about the attribute as well as their realization about other attributes to be more important gave the undesirable outcome.

Comparison

For this particular attribute only the level comparison among teams within the offices is 95 % significant with the coefficient 0.11982 which is lowest among the coefficients of all the significant levels. This indicates that comparison is considered as an important attribute to determine energy saving by the respondents even after the attribute feedback type which has second lowest

coefficient. Moreover the positive coefficient of the level comparison among teams within offices shows that this level has positive impact on the decision making. The other levels are considerably very low (<0.1) and with negative coefficients indicates that these levels have considerably negative impact on decision making. The reason behind comparison within teams in office being significant then other two levels (teams outside offices and companies average) must be the known identity of the participants participating in the energy saving program and receiving information about them can lead to group-dynamic consequences (Siero, 1996). Another reason must be the existence of another team with whom they may compare themselves will drive the participants intention to save energy when the team is physically present in front of them rather than a team from different location with only few known faces. And the reason behind rejection of company's average must be the no clear comparison with any team.

Information screen

The attribute information screen performed well in the MNL model with the attribute level of public screen scoring significance of 99% with positive coefficient of 0.14093. Displaying information on public screen also induce the societal pressure to perform well as compared to other teams. Hence, respondents decision making considered public screens as one of the important attributes in saving energy. From the output table it is clear that it is even more important than comparison with teams outside office and company's average or even the feedback period does not matter most for the respondents to get motivated for saving energy.

Goal setting and Competition (Gamification)

These two variables were introduced under a single mask of "Gamification". This was an attempt to introduce gamification with the use of smart meter data. Since gamification has been indicated as very useful instruments in changing human behavioral intention, its performance in collaboration with the smart meter data was checked in this study. These two variables performed extremely significant with the highest coefficient of 0.37073 being scored by competition and a slightly lower than that scored by the factor goal setting (0.24394). These variables had only two levels yes and no. The positive and even higher coefficients of these variables compared to the coefficients of significant variables indicates that these variables were most preferred in determining energy saving. Both the variables were almost similar with competition having an additional feature of receiving financial reward. And the results shows that getting reward for their performance is of utmost important than just setting up the goal to win. Also according to the hypothesis these levels had a positive impact on decision making and the MNL outcome proved it to be true. The most significance for these attributes shows that inducing social-psychological interaction within employees using data from smart meter can give good results in the form of energy usage reduction.

4.4.2 Relative importance of significant attributes (range)

After discussing the interpretations of the performance of different attributes according to their path worth utility (β-estimate)and significance, in this section the relative importance of the significant attributes with each other is examined to know which of them are most influential. Setting up competition using smart meter data proved to be the most influential variable in determining intention to save energy. In order to reach this conclusion, the range of each attribute has to be calculated and range is calculated by adding the values of lowest and the highest level of attribute. Then to know the relative importance of each attribute the range of that attribute has to be divided

by the sum of all ranges. For instance the range of the attribute comparison is calculated by summing the absolute (without negative or positive influences) coefficients of the lowest level (comparison within office) and the highest level (office average) i.e. 0.11982 + 0.04048 = 0.16030. the sum of all the ranges is equal to 2.03678, so the relative importance of specific attribute is calculated by dividing 0.16961 by 2.03678 which gives 12.72%. All the calculations are shown in table 18 and the results are presented in figure 26.

Ranges		Relative importance
Feedback type	0.25826	13.38%
Comparison	0.16030	8.31%
Information screen	0.28186	14.61%
Goal setting	0.48788	25.28%
Competition	0.74146	38.42%
Sum	1.929760	100%

Table 18 Range calculation of the significant attributes

Figure 26 illustrates that the most influential variable in determining the energy saving behavior in office building is the competition. Therefore, it can be said that if the competition is initiated in office building using the smart meter data, the employees will ensure maximum energy saving. In this study competition is referred as gamification element which has a feature of receiving reward if the team wins. This shows that employees gets motivated to save energy when they have motif of receiving reward. Although receiving reward is not the main finding of this study, but introducing game elements using smart meter can be an important step to ensure energy saving in office building. Another variable which has highest relative importance is the goal setting which is also a part of gamification. This shows that if additional information regarding goals to reach the target are provided to them, they will act accordingly to make their best possible effort to save energy. Information screen and feedback type are almost close to each other with the percentage 15, 13 respectively. The least important from the significant variables is comparison with 8% importance. This shows that after the game elements, disaggregation of feedback on appliance level and displaying processed feedback on display hung in public areas are the most influential factors that can motivate employee's to save energy. And lastly comparison accounts for the least but more important than insignificant attribute feedback period to determine energy saving.

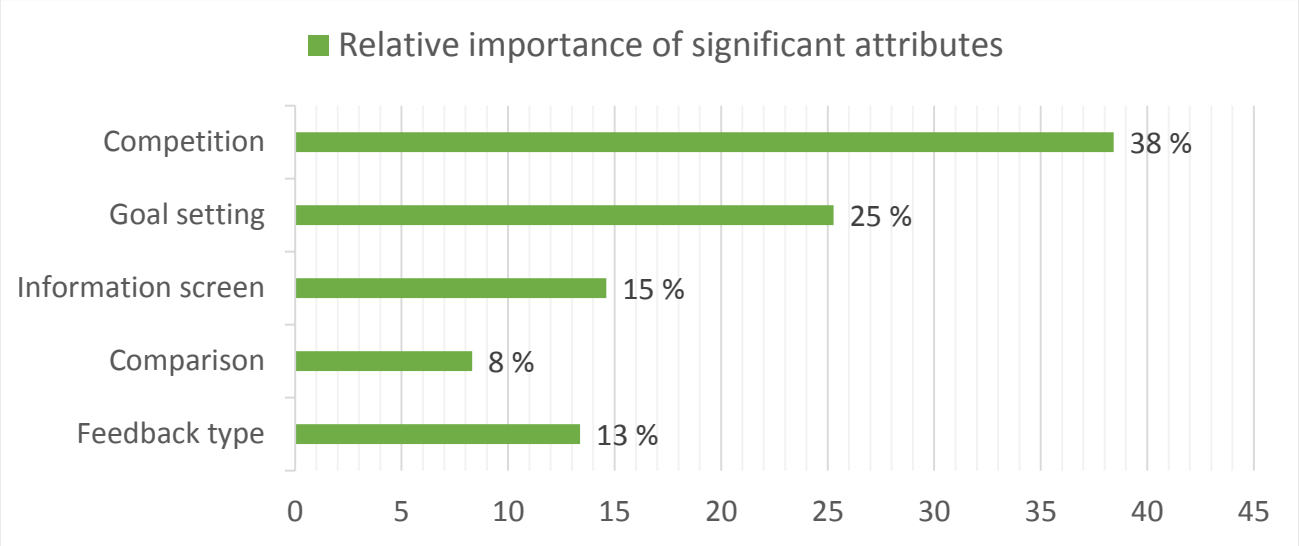


Figure 26 Relative importance of significant attributes

4.5 Results of hypothesis

In chapter 2, six different hypothesis were outlined based on literature review of socio-demographic characteristics and behavioral, attitudinal and psychological factors. The hypothesis were constructed to evaluate the combination of these factors with respect to energy and environmental concern which can ultimately determine the employee's behavioral intention to save energy and the opinion for different preferences among the participant group working in office environment. In this section, these hypothesis will be tested in order to get more information about behavior regarding energy issues and opinion for the preferences of the sample group of respondents.

Hypothesis 1 :

Women are more considered about the environmental and energy issues and therefore have higher intention to save energy.

The objective of this hypothesis is to determine if women are more considered about the environmental and energy issues than men. This hypothesis can be tested from the outcome of the questions asked to the participants in section 1 about their awareness regarding energy saving (Question 1), perceived control effectiveness (PCE) (Question 3) and their activities at home and office with energy saving concern (Question 4 & 5). All the questions were asked on 5 point Likert scale with options ranging from not at all aware to extremely aware, totally disagree to totally agree, and never to always respectively. PCE questions was asked based on idea that if people disagree on this statement, they agree that there is problem regarding energy saving and it needs to be solved. The outcome of these questions shows that 81.25% of the total women participated and 72.87% of the total male participated in the survey are aware of energy concern and they perform activities with energy saving concern. Therefore, since the percentage of women with the concern is higher than that of men, this hypothesis can be confirmed. Therefore, the behavioral intention of women to save energy can be said to be greater than men.

Gender	#	No	Neutral	Yes	% Yes
Male	129	21	14	94	72.87
female	64	8	4	52	**81.25**

Table 19 Output of hypothesis 1

Hypothesis 2 :

Highly educated older women are more engaged in energy issues and therefore the intention to save energy is higher among them.

To test this hypothesis, participants were grouped by gender, education and age. The age group is divided into two groups namely 35 and younger and 35 and older. Level of education is divided into two groups bachelor & lower and master & higher. To test this hypothesis, outcome of questions regarding awareness regarding energy saving (Question 1), perceived control effectiveness (PCE) (Question 3) and their activities at home and office with energy saving concern (Question 4 & 5) are considered for the analysis. To validate this hypothesis, the respondents having energy concern of a particular group are compared to the respondents in same group combined with age, level of education and gender. The result of the analysis shows that all women above age 35 are engaged in energy issues although the respondent group size is less. This shows that the level of education does not matter for engaging in energy saving issues. Therefore, the hypothesis can be rejected. However from the output table it can be observed that women are over all more engaged in energy issues compared to men, especially the age group above 35. Therefore, to conclude behavioral intention of not only highly educated older women, but also less educated older women to save energy is higher than other groups.

Age	#	No	Neutral	Yes	%Yes
Male <35 low educated	53	10	8	35	66.04
Male <35 high Educated	61	8	5	48	78.69
Male >35 low educated	6	0	1	5	83.33
Male >35 high Educated	9	3	0	6	66.66
Female <35 low educated	28	4	1	23	82.14
Female <35 high educated	29	4	3	22	75.86
Female >35 low educated	4	0	0	4	100
Female >35 high educated	3	0	0	3	**100**

Table 20 Output of hypothesis 2

Hypothesis 3 :

Youths are more likely to be sensitive about environmental issues and therefore have higher intention to save energy.

Table 21 illustrates the output of hypothesis which is based on question regarding energy saving (Question 1), discussing with others opportunities to save energy (Question 2), statement on perceived control effectiveness (PCE) (Question 3), and their activities at home and office with energy saving concern (Question 4 & 5). The outcome of the analysis shows that people older than 35 are

more sensitive about environmental issues as compared to the younger. Therefore this hypothesis can be rejected and from result it can be concluded that intention to save energy is higher among older people than younger people.

Age	#	No	Neutral	Yes	%Yes
<35	171	24	22	125	73.10
>35	22	2	0	20	**90.90**

Table 21 Output of hypothesis 3

Hypothesis 4 :

Highly educated people are more concerned about the impact of their action on environment, hence possesses higher intention to save energy.

The output of this hypothesis is illustrated in table 22. To test this hypothesis only the level of education is considered in the analysis. The questions included to test this hypothesis are same as that of hypothesis 3. The results shows that respondent with education level master and higher are more concerned about the impact of their action on environment since 79.60 % agreed to the questions compared to respondents with education level bachelor and lower (77.17%). Therefore this hypothesis is confirmed although the difference between both the categories is not big. This gives the impression that highly educated people inherits higher intention to save energy then the people with comparatively lower education level.

Age	#	No	Neutral	Yes	%Yes
Bachelor & lower	92	13	8	71	77.17
Master & higher	98	9	11	78	**79.60**

Table 22 Output of hypothesis 4

Hypothesis 5 :

Western people may have different preference than non-western people regarding energy issues and therefore have higher intention to save energy.

To test whether the concern regarding energy issues is more among western people compared to non-western people same questions as considered in hypothesis 3 are used to analyze. This hypothesis is confirmed since the result shows that 76.56% of respondents belonging to western geographical region have concern regarding energy issues compared to 74.42% of people from non-western region. However, the difference in respondent group is double and the different in percentage of having concern for energy issues is not big, still from the results it can be said that western people have higher intention to save energy than the non-western people.

Job location	#	No	Neutral	Yes	%Yes
Non-Western	129	18	15	96	74.42
Western	64	8	7	49	**76.56**

Table 23 Output of hypothesis 5

Hypothesis 6 : Cross validation with the output of MNL analysis from optimal model.

Preferences can vary among people from different work sector.

This hypothesis is tested based on the questions in section 3 part A of the survey, regarding the importance of various attributes presented in choice experiment and these questions can be found in appendix A. MNL analysis of choice experiment indicates that importance of competition, goal setting, appliance level feedback, comparison among teams within office are in descending order, with feedback characteristic non-significant. However, the opinion of respondents somewhat vary when the attributes are shown to them combined in choice sets and the importance of each of them is asked separately. For the people working in built environment sector, comparison is most influential attribute to save energy, appliance level feedback is important to save energy in case of people from software, information and telecommunication and monthly feedback in case of respondents from education and other category is the highly influential attribute in determining energy saving. From this outcome the hypothesis can be rejected since the people from education and other category has the higher preference for the same attribute monthly feedback period.

However, majority of the respondents indicated all the attributes are highly important in energy saving since the number of respondent choosing high level of importance is more than that in low and neutral category. Still the output of analysis shows that competition is not indicated by any of the group to be most influential in energy saving as observed from the output of MNL analysis, although the differences in preferences for different attributes is not big. The surprising outcome is observed for the attribute feedback period, which did not show any significance in the choice experiment, moreover its impact on choice making was found to be negative. This shows that respondents did not consider the attribute feedback period in choice making since the combination of other attributes level were more dominating when they considered all the attributes together in choice experiment and on the other hand when asked to indicate the importance of different attributes separately two of four categories showed preference for feedback period in determining behavioral intention to save energy. From this finding it can be concluded that indirect feedback (monthly feedback) is important when it is considered individually, however with combination of other attributes its level of importance decreased. Additionally, gamification elements when brought together with different attributes and levels are highly important and unimportant when considered separately. However, the unwillingness for indicating gamification elements to be motivating when considered separately cannot be accepted completely since in all the cases except software, information and telecommunication the difference is hardly significant when compared to most important attribute of these categories.

Work sector	Attributes	#	Low	Average	High
Built environment	Appliance level data	62	7	7	48
	Real time feedback	62	7	11	44
	Monthly feedback	62	3	9	50
	Comparison	62	0	9	**53**
	Goal setting	62	1	9	52
	Competition	62	7	10	45

Education	Appliance level data	26	3	3	20
	Real time feedback	26	3	3	20
	Monthly feedback	26	2	2	**22**
	Comparison	26	4	4	18
	Goal setting	26	2	6	18
	Competition	26	1	6	19
Software, information and telecommunication	Appliance level data	38	2	3	**33**
	Real time feedback	38	3	10	25
	Monthly feedback	38	5	3	30
	Comparison	38	4	9	25
	Goal setting	38	2	6	30
	Competition	38	2	13	23
others	Appliance level data	67	9	7	51
	Real time feedback	67	10	11	46
	Monthly feedback	67	4	4	**59**
	Comparison	67	5	12	50
	Goal setting	67	4	7	56
	Competition	67	6	10	51

Table 24 Output of hypothesis 6

4.6 Additional model

After analyzing the optimal model with all the data from all the respondents as input, some more models with specific group samples considering the personal characteristics are studied in this section. Analyzing separate groups enables to draw conclusions determining the difference in effect of influential attributes on different groups. The different group categories considered for the analysis are as follows:

Group 1 : Male, participated in energy saving program

Group 2 : Male, not participated in energy saving program

Group 3 : Female, participated in energy saving program

Group 4 : Female, not participated in energy saving program

Reasoning for characteristics included in grouping respondents

Gender : It is always interesting to observe the differences in the responses of male and female for any study since it can gives insight in their opinion. Also literature argues that female are more concerned for energy then men. Therefore to analyze as to what extent their responses differ from each other this characteristics is included in group formation. Another attribute included is participation in energy saving program undertaken by the management. People who already has participated in any energy saving can be considered to have experience, understanding and importance of it. And since this study is related to more or less similar energy saving approach there opinion can significantly differ from those who has not been exposed to such issues and programs.

Reasoning for characteristics not included in grouping respondents

Apart from the above mentioned characteristics there are various other attributes that are important to take into consideration but not included in group formation. Age and education of respondents can have significant difference in their opinion regarding energy saving as mentioned earlier in the socio-demography literature. But the respondents participated in this study are majority between age 18 to 34. Out of 193 respondents 171 are between 18-34 which is considered as young age group and only 22 of them in category 35 and above. Therefore including this unbalanced age category for group analysis would not make significant group category and thus ineffective for interpreting the results of MNL afterwards. Similarly for education level, out of all the categories bachelor and master consisted of majority of respondents. And since both of these categories can be considered as highly educated, dividing respondents based on education is not viable as there is no clear differences between highest and lowest education.

4.7 MNL analysis of group formed

Attributes		Attribute levels	Part-worth utility **Group 1**	Part-worth utility **Group 2**	Part-worth utility **Group 3**	Part-worth utility **Group 4**
Feedback type	1	Appliance level information	**0.15125****	**0.16995*****	0.07135	0.12423
	2	Overall information	**-0.15125****	**-0.16995*****	-0.07132	-0.12423
Feedback period	1	Daily	0.13388	-0.07635	-0.06218	**-0.36946****
	2	Weekly	0.02014	0.08017	0.20463	0.03126
	3	Monthly	**-0.22046***	-0.12037	-0.07637	0.23590
	4	Real time	0.06644	0.11655	-0.06608	0.10230
Comparison	1	Teams within office	**0.17491***	**0.17116****	0.02425	-0.00841
	2	Teams outside office	0.01110	-0.10500	**-0.27721****	0.00361
	3	Company's average	-0.18601	-0.06616	0.25296	0.00480
Information screen	1	Public screen	**0.17373****	**0.12998****	0.08547	**0.19995****
	2	Personal screen	**-0.17373****	**-0.12998****	-0.08547	**-0.19995****
Goal setting	1	Yes	**0.15745****	**0.32286*****	**0.24550*****	**0.23425****
	2	No	**-0.15745****	**-0.32286*****	**-0.24550*****	**-0.23425****

Competition	1	Yes	**0.41763*** **	**0.37670*** **	**0.18533** **	**0.51393*** **
	2	No	**-0.41763*** **	**-0.37670*** **	**-0.18533** **	**-0.51393*** **
Constant			**1.69704*** **	**2.12132*** **	**1.71045*** **	**1.56807*** **
***1% **5% *10% Significance						

Table 25 MNL output of the formed groups

4.7.1 MNL interpretation of the groups

Goal setting and Competition (Gamification)

For all of the four groups namely males participated and not participated in energy saving program and female participated and not participated in energy saving program, the level yes for gamification attributes goal setting and competition determined a significantly positive impact on choice making. This indicates that the respondents from all four groups preferred gamification elements shown in the description of survey, to be an instrument that can determine their behavioral intention to save energy. The coefficient for the attribute competition has the highest and 99% significant coefficient (0.51336) for the group females who has not participated in any energy saving program as compared to the respondents in three groups and also highest when compared to all other variables included in the choice experiment. Following this group, the groups males participated in energy saving, males not participated in energy saving program and females participated in energy saving program showed the values of coefficient in descending order respectively. But still for the groups male participated and not participated in energy saving program, the coefficients for gamification scored second highest significant values 0.41910 and 0.38878 respectively with 99% significance when compared to all other attributes. Only the group female participated in energy saving program indicates lower coefficient with 95% significance, even lesser than that of variables goal setting for the same category which is 99% significant and has coefficient 0.24581. This indicates that females who has experience of energy saving program thinks goal setting is more important than getting reward by competing with others to save energy saving.

Therefore it can be said that these women thinks when both variables have same purpose except getting reward by competition why not to compete with ourselves by setting up goal rather than earning appreciation by getting reward for purpose of being environmental concern. Which also shows there self-efficacy behavior and personality trait of protecting themselves and their families as observed in literature. Moreover, as goal setting is the very likely approach used in various energy saving program, 99% significance indicates that they must be exposed to something similar during the energy saving program they participated in to some extent which motivated them to consider it for making choice. On the other hand the respondents of same gender but not having experience of energy saving program showed altogether opposite effect. Although they also have the similar trait, with no experience of energy saving program they must be fascinated with the additional features of competition such as getting points that lead to getting reward. As a newbie to such approach to save energy, it is expected that when both the variables have same purpose and among them one (competition) is ensuring getting points for energy saving, ultimately in a form of reward, it can be

said to determine attractiveness and thus higher preference. This also applies for the males with no experience of energy saving. For men both categories preferred competition over goal setting, which shows the fact that men are usually considered more competitive whether it is sport, education, societal status is true and hence it can be also said for energy saving.

Information screen

Preference for Information screen also showed similar behavior as that of game elements. Respondents preferred getting information on the public screen than on their personal screen. When information about their own group is brought forward in front of everyone, it can naturally makes people conscious about others observing their consumption pattern and they will continuously strive to improve it so as to improve their image in front of others. Also characteristic control belief in theory of planned behavior states that individual's beliefs about the existence of factors that may facilitate or hamper performance of the behavior-adoption. Therefore with public screen in place societal pressure can be said as factor that has the ability to improve performance of the behavior adoption. Three groups of respondents except women participated in energy saving program showed 95% significance with coefficient more than 0.13 shows that displaying energy consumption on public screen will surely motivate them to save energy and it is also almost equally important as attribute goal setting for the males, participated in energy saving program. Whereas on the other hand women who has experience of energy saving program indicates surprising outcome as they didn't consider public screen in choice making. All other categories showed similar level of significance, participants in this category showed altogether opposite opinion. Keeping their experience in energy saving program in mind, for these participants behavioral intention to save energy must be highly motivated by other attractive variables used in choice experiment than the information screen since both levels has no significance.

Comparison

Self-efficacy which is also referred as personal efficacy is an individual's confidence in their own ability to achieve intended results. The group of women who participated in energy saving program has shown a peculiar behavior in choosing levels of various attributes that shows their self-efficacy characteristics. For the variables competition there response was observed to be less significant than other groups, also for information screen that was intended to create societal pressure by displaying data publicly showed no significant result, and now the variable comparison in which they clearly indicated negative impact for level comparison with teams outside office, and also no significance for teams within office but a highly positive coefficient of 0.24405 (although not significant) for the impact of variable company's average in determining energy saving shows their self-efficacy characteristics meaning they don't need to compare themselves with others to save energy and they are confident enough on their own ability to save energy. Selection of company's average must be to set benchmark as to what level of consumption should be considered in order to reach the target of saving energy effectively. For male categories who have and don't have experience of energy saving program showed positive and significant impact on decision making for the level comparison among teams within offices which also shows their competence behavior as discussed above in gamification.

Feedback period

Feedback period as seen earlier in the optimal model, didn't show any significant result for the groups male participated in energy saving program and female not participated in energy saving program.

Level monthly feedback showed negative impact with 90% significance for group male with experience and showed highly positive impact on choice making with coefficient 0.23659 (although not significant) for group female not experienced in energy saving program. This level has the least saving ability according to literature as compared to other levels in the variable. And the unfavorable selection for this level by experienced and favorable selection by inexperienced respondents rightly indicates the difference in opinion of people who has experience of energy saving program and who doesn't have. Similarly for level daily feedback, which ensures second most energy saving according to literature rightly indicates the inexperience level of female participants in energy saving program by determining it to be 95% negative coefficient of 0.37032 meaning no favorable to save energy. And on the other hand positive coefficient 0.12882 (although not significant) shows the clear understanding of the importance of this level to save energy by male respondents having experience in energy saving program.

Feedback type

The MNL result shows that only male category desired to have positive significance on energy saving for the level appliance level data. Appliance level data is considered as direct feedback which ensures high energy saving than the level overall data which is an indirect feedback and determines lower energy saving according to literature. For female also both categories has positive impact on energy saving for the level appliance level data but the there is no significance observed. This also shows that for female other attributes are of more importance then on what level the information should be received. For male participants who participated in energy saving program, this level is of least important after level feedback period, but for male participants who has not participated in energy saving program it is highly important after gamification elements.

4.8 Mixed Logit

Mix logit is the outcome of advancement in the previous MNL model which no longer constraints researchers to use models with closed-form solutions that may lead to unrealistic behavioral requirements. In fact, the extension of previous MNL model has made possible for the random parameter model to accommodate unobserved preference heterogeneity (Sarrias M. D.). Previously using MNL model, the effect on different significant attributes in making decision to save energy has been studied. Now, a mixed logit model is used to capture the heterogeneity of respondents in those influential attributes. Mixed Logit itself is a big term that comprises of various different models that can determine various different outputs as per researcher's requirement. The model within ML that deals with the heterogeneity among the respondents considering the levels of variables as random parameters is called the Random Parameter Logit model (RPLogit). Using the NLogit software package, firstly the multinomial model determine the β-estimate of variable levels, following this with 10,000 halton shuffle draws, the RPLogit is conducted. The random parameters in RPLogit model are the levels of attribute in the choice experiment. Table 26 shows the output of the RPLogit model consisting the β-estimate of random variables and their standard deviation when the distribution is considered as normal in the model.

Attributes		Attribute levels	Part-worth utility	Significance	St. deviation	Significance
Feedback type	1	Appliance level information	0.15846	***	0.30056	***
Feedback period	1	Daily	-0.05122	-	0.06296	-
	2	Weekly	0.09304	-	0.15017	-
	3	Monthly	-0.10111	*	0.07942	-
Comparison	1	Teams within office	0.15965	***	0.06995	-
	2	Teams outside office	-0.08946	-	0.47648	***
Information screen	1	Public screen	0.18999	***	0.38250	***

Goal setting	1	Yes	0.28720	***	0.30484	***
Competition	1	Yes	0.46835	***	0.33772	***
***1% **5% *10% significance						

Table 26 Mix logit output of studied attributes along with their β-estimate, level of significance and st. deviation

4.8.1 Heterogeneity / homogeneity

To determine the heterogeneity, the standard deviation of the main attributes in analyzed in the mixed logit model. So, in this model the significance of the standard deviation is considered to determine the heterogeneity. Table 26 illustrates the results of the standard deviation of the random variables. Standard deviation indicates that the choices varies between the average coefficient and plus or minus one standard deviation. Heterogeneity of the model depends upon how large is the significant difference between the β-estimate minus and plus one. So , if the difference is large, then the model is said to be heterogeneous. Levels with 99% significance namely appliance level data, public screen, goal setting and competition are all heterogeneous. For the attribute comparison, the levels comparison with teams outside office is also significantly heterogeneous. Although the levels from variable feedback period and level comparison with teams within offices are not significant, but they showed the heterogeneous nature as well except for the level monthly feedback. Complete information about the height of heterogeneity and its influence is illustrated in the figure 27. Dark green bars represents the levels with 99 % significance and the light green bars represents the levels below 90% significance. After analyzing the model, heterogeneous among the levels in all attributes is clearly visible which shows that there is large variation in the preferences made by respondents which also states that human behavior and psychology varies highly from person to person.

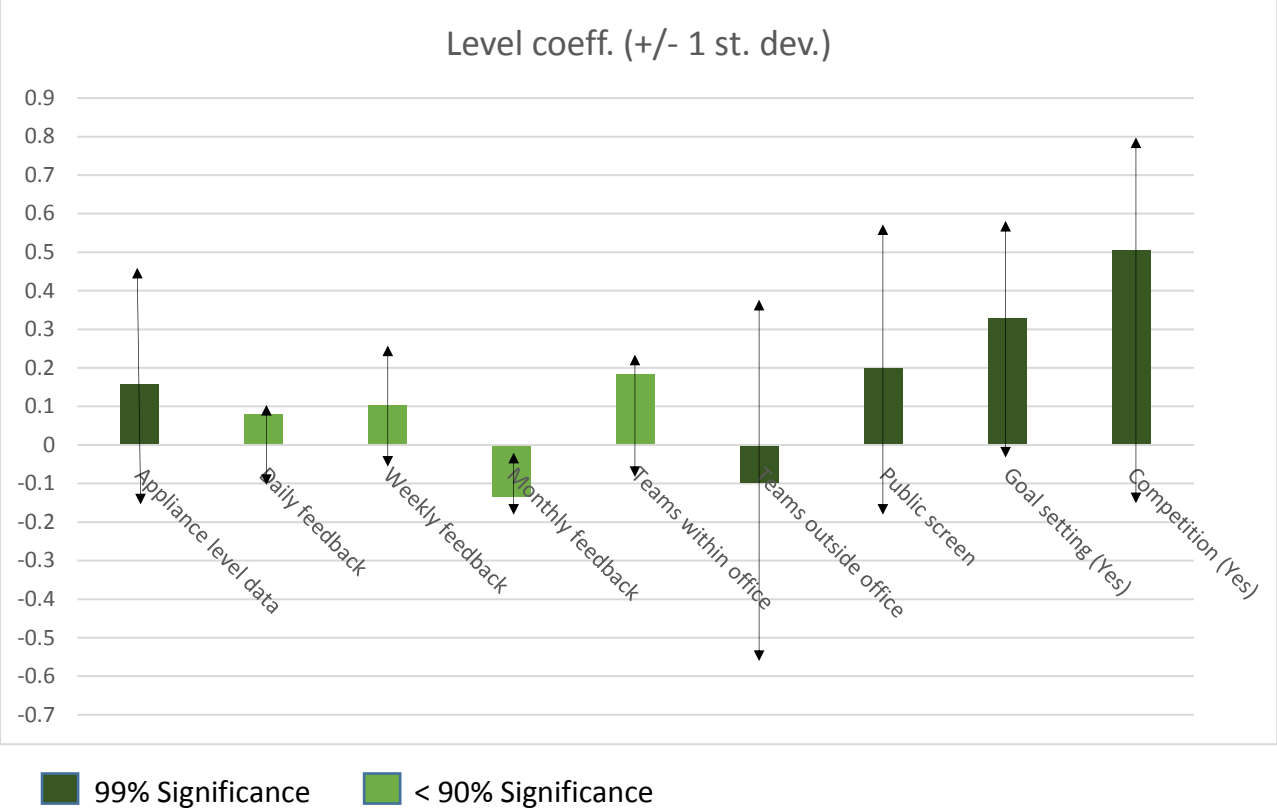


Figure 27 Studied attributes showing St. deviation

4.9 Choice set preference

In order to determine the most preferred alternative chosen by the respondents amongst the alternatives presented in choice sets, summation of the β-estimate of all the variables in single choice set is computed. The alternative with the highest summation is considered to be the most preferred and one with the lowest as least preferred. Table 27 illustrates the preferences of all the alternatives presented to the respondents. The summation of coefficients in alternative 14 is highest among all and it indicates that this particular alternative has the maximum positive impact on energy saving among employees. This also shows that the levels presented in this alternative namely appliance level data, real time feedback, comparison among teams within offices, information displayed on public screen and inclusion of game elements goal setting and competition have the maximum potential to motivate employees in office buildings to save energy. Also these findings goes in line with that mentioned in literature. The second most preferred alternative 7 consists of the levels same as that in most preferred alternative except for the attributes feedback period and comparison. In this particular alternative respondents indicated the preference for weekly feedback period and comparison with teams outside office.

Output table also determines the least preferred alternatives. Alternative 13 does not seem to have potential in motivating employee's intention to save energy. This least preferred alternative consists of the levels overall information, real time feedback, company's average, public screen and no game elements. Comparing this alternative with the most preferred alternative, real time feedback and public screen are the only common level in both. This indicates that the respondents did not find feedback period to motivate them in saving energy which is similar to the results from optimal MNL model. But for public screen optimal MNL model has positive and significant impact on decision

making. From this it can be said that although least preferred alternative consists of public screen but the decision for that particular alternative to be least preferred is made on the basis of other levels such as no game elements and overall information. Following this the second least preferred alternative is alternative 3 that consists of overall information, monthly feedback period, teams outside office, personal screen, goal setting and no competition.

Alternative	Feedback type	Feedback period	Compa-rison	Information screen	Goal setting	Compe-tition	Summation of coefficients
14	Appliance level information	Real time	Teams within office	Public screen	Yes	Yes	**1.06225**
	0.12913	0.05800	0.11982	0.14093	0.24394	0.37073	
7	Appliance level information	Weekly	Teams outside office	Public screen	Yes	Yes	**0.88201**
	0.12913	0.07662	-0.07934	0.14093	0.24394	0.37073	
12	-0.12913	-0.04305	0.11982	0.14093	0.24394	0.37073	0.70324
1	-0.12913	-0.09157	-0.04167	0.14093	0.24394	0.37073	0.49323
4	0.12913	-0.09157	0.11982	-0.14093	-0.24394	0.37073	0.14324
6	-0.12913	0.07662	0.11982	-0.14093	-0.24394	0.37073	0.05317
16	0.12913	0.05800	0.11982	-0.14093	0.24394	-0.37073	0.03923
9	0.12913	-0.04305	-0.04048	-0.14093	-0.24394	0.37073	0.03146
5	0.12913	0.07662	-0.04048	-0.14093	0.24394	-0.37073	-0.10245
15	-0.12913	0.05800	-0.07934	-0.14093	-0.24394	0.37073	-0.16461
10	-0.12913	-0.04305	0.11982	-0.14093	0.24394	-0.37073	-0.32008
2	0.12913	-0.09157	0.11982	0.14093	-0.24394	-0.37073	-0.31636
8	-0.12913	0.07662	0.11982	0.14093	-0.24394	-0.37073	-0.40643
11	0.12913	-0.04305	-0.07934	0.14093	-0.24394	-0.37073	-0.46700

3	Overall information	Monthly	Teams outside office	Personal screen	Yes	No	**-0.56776**
	-0.12913	-0.09157	-0.07934	-0.14093	0.24394	-0.37073	
13	Overall information	Real time	Company's average	Public screen	No	No	**-0.58535**
	-0.12913	0.05800	-0.04048	0.14093	-0.24394	-0.37073	

Table 27 Alternative preferences according to the part worth utility calculated from MNL model

The above mentioned preferences are for the choice set. And to observe which levels can be incorporated in energy saving program using smart meter data to change employee's intention to save energy, the levels with highest coefficients can be considered to be effective as they are preferred most by the respondents. Therefore, the variables appliance level information, weekly feedback, comparison among teams within office, public screen, goal setting and competition has the highest coefficients compared to other levels in respective attributes and hence can be considered for energy saving program. And all these variables also showed the significance for determining intention to save energy except the attribute feedback period.

Attributes	Attribute levels	Part-worth utility	Significance
Feedback type	Appliance level information	**0.12913**	***
Feedback period	Weekly	0.07662	-
Comparison	Teams within office	**0.11982**	**
Information screen	Public screen	**0.14093**	***
Goal setting	Yes	**0.24394**	***
Competition	Yes	**0.37073**	***

Table 28 Most preferred attributes according to highest co-efficient

Lastly, if these levels with the highest coefficient among the respective attributes are presented to the employees in office environment to save energy it would look like figure 28. From the result

analysis, if figure 28 is shown to employees in office environment, it will have the major impact on energy saving.

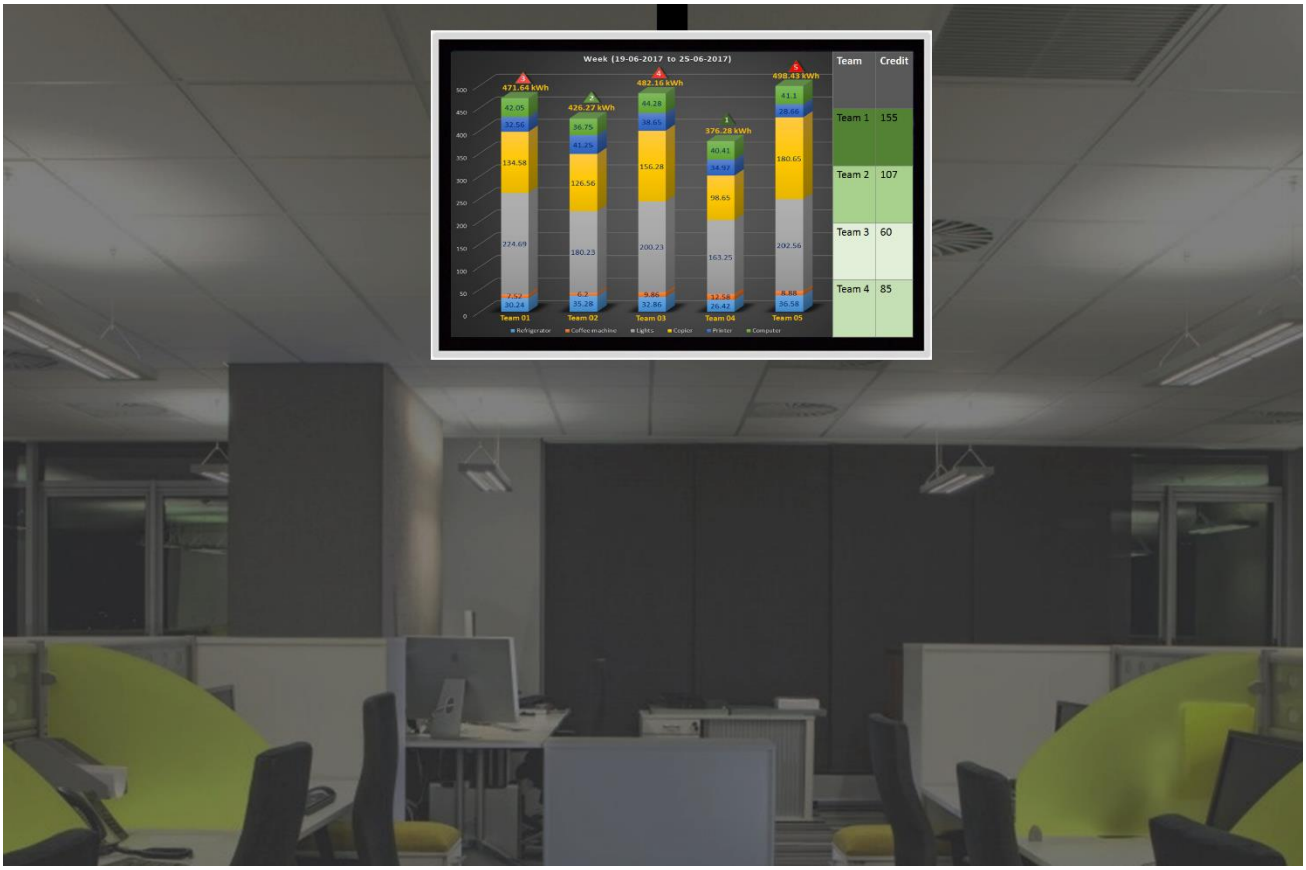


Table 29 Realized energy saving intervention strategy from the MNL output

5. Conclusion

Last but not the least, this chapter draws the conclusion of this research study. Firstly general conclusion would be discussed by answering the research questions. Following would be the sections consisting societal and scientific relevance. In addition, some recommendations are outlined for the potential stakeholders for this topic and for future investigations of the related studies as well. And lastly, in discussion section the overall evaluation of this research in terms of possible weaknesses of this research are discussed.

5.1 General conclusion

Through this graduation thesis, a vague stream of energy consumption in the office environment is explored and further possible measures to reduce it by changing behavioral intention in favor of energy saving is studied. As aforementioned, this vague field has been explored by various researchers and attempted to have impact on energy saving with various different approaches. This particular project focuses on saving energy using the smart meter data of the energy consumed by the employees. The aim was to realize if smart meter data has the potentiality to reduce energy consumption in the office environment. Although various researchers focused on reducing household energy consumption using smart meter data, this approach for energy reduction in office building is an attempt to shed lights in this less explored office energy consumption sector. This study explores the possibilities to motivate employees in office building by making them available their energy consumption pattern in a meaningful way by giving them feedback of their energy consumption. And with their energy usage information additional factors that are said to be efficient in changing behavioral intention such as pro-environmental behavior, that can drive their attitudinal behavioral and intention to save energy are studied and their impact on decision making of the respondents to save energy is explored.

The main research question formulated to find the answer to this aim is:

"How can feedback on energy consumption data change the energy consumption behavior of employees in an office-type workplace?"

By conducting a state choice experiment targeted to the employees working in office environment and after analyzing the results from the data thus gathered, answering this question is attempted by answering the sub questions for this research which are outlined below.

How does the energy consumption behavior of employees in office type buildings look like ?

Through the results analyzed in the descriptive analysis, the employees who participated in this study has a strong desire to reduce their energy consumption in offices. The positive concern for the environmental benefits by consuming less energy, their everyday activities at office and at home with energy saving concern, their relatively high frequency of discussing with their colleagues about the possible ways to save energy shows that their consumption behavior is highly in accordance to saving energy and bringing out positive in change society by contributing to a greener environment. Although unexpected, but almost 50% of the respondents indicated their participation in energy saving program undertaken by the management of their office shows that people's positivity towards ecological concern is increasing day by day through such program which can surely have impact on energy saving and determine their environmental friendly behavior.

How can energy consumption data help organization's management to change the energy consumption behavior of their employees?

In this research it is argued that making the employees in office environment aware about their energy consumption through feedback on their energy use increases their level of informedness as they ultimately get insight in their energy consumption by knowing how much energy they use while working in office and at what time during the day. As observed in the literature, it is extensively highlighted that feedback on energy consumption can ensure energy saving (FIischer, 2008; Bonino, 2012). Therefore In this study, an explicit insight on the effect of feedback characteristics such as feedback period which underlines the direct and indirect feedback and feedback type which highlights information disaggregated and provided on appliance and building level determining behavioral intention to save energy in office envelop is examined. Analyzing the data indicates that providing energy usage information daily and weekly (indirect feedback) has higher effect on intention to save energy as compared to real time (direct feedback). Although the results are not significant but the positive coefficient shows the inclination towards indirect feedback. Literature put forward the effects of these two feedback types oppositely to this finding. The difference in feedback on appliance level and building level has not been researches broadly before. Result analysis outlines that receiving energy consumption of each and every appliance used resulted in higher intention to energy saving then the building level information. From this findings it can be concluded that indirect feedback provided on appliance level can ensure higher energy saving.

Which variables can be implemented in the energy saving applications so as to provide meaningful feedback to the employees motivating them to save energy ?

Along with feedback type and feedback period as mentioned above, the gamification elements goal setting and competition performed extraordinarily well in the study. Gamification has been used in various studies related to energy saving and found positive influence of it in determining energy saving. However, its use in collaboration with smart meter data has not been widely explored. The findings from study clearly shows that these element has the strongest impact on employee's decision making to save energy. As setting up goal depending on their consumption pattern enables them to understand until what extent their energy consumption would determine energy saving and competing with other would increase their social status, give them points in form of reward ultimately resulting in save energy.

The result analysis shows that comparing own energy consumption with teams inside office has positive influence on energy saving intention. Making comparison with others enables an individual to see where he and his team stands in the energy saving which advances their knowledge. This would create a sense of competition to perform better. However, some people have faith in their ability and does not desire to compare with anyone and just need the idea as to set benchmark under which they should keep their consumption. For this purpose, the level company's average was introduced. But it was rejected since respondents preferred encouraging their motives for energy saving such as ambition and competition by comparing with others.

However, feedback characteristics are essential to make respondents aware of their consumption. Therefore keeping information characteristics as base further integration of game elements, normative comparison can add excessively to the energy saving intention.

Therefore to sum up the variables that can be integrated using smart meter to influence employees intention to save energy are :

- *Appliance level data*
- *Indirect feedback*
- *Comparison with teams inside office*
- *Gamification elements : Goal setting and competition.*

How can these variables useful for energy saving be shown to employees using feedback displays to enable them get insight in their consumption data and drive them to save energy?

All the variables mentioned above have energy saving capabilities to some extent. Another important factor studied in this research is the best possible way to show data to employees visualizing which they can be motivated to save energy. Results indicates that showing data on the public screen which is visible to all has potential in determining behavioral intention to save energy. However, personal screen variable is rejected by the employees, which shows that societal pressure for performing good when their social status is at risk also induced their intention to save energy. Therefore, showing their consumption information on screens hanged in public areas will provide them information about their status and will also bring in pressure that would drive them to save energy.

5.2 Managerial implications

The research carried out under this graduation thesis contributes to better understanding of energy saving measures in a form of energy saving program using the information of energy consumption of employee in office environment using smart meter that would motivate the behavioral intention to save energy. The focus of this study is to find which attributes influence the employees in office environment to save energy. As the issue of energy conservation is gaining popularity with every day passing, so does the energy saving program influencing people to save energy. Although the invention of smart meter can be traced back to 1990's its effective use in energy saving is still a big topic of discussion. With the advancement in technology, smart meters can be better configured to integrate energy saving program in a meaningful and efficient way. This research is thus an attempt as to how can this integration be effective in terms of energy saving. Therefore, firstly there is a need to understand the current consumption behavior of the employees in office buildings and how can they be influenced to save energy through such integration. Knowing how the consumers react to different feedback types, normative comparison, information display, game elements it will benefit the organizations to make an efficient energy saving program using these variables and thus benefit in minimizing their energy bills and which ultimately result into benefitting the society by making it environmentally green.

From the model estimated all the variables except feedback period showed the significant contribution in determining energy saving. The main reason behind this can be the unclear understanding of receiving energy feedback at different times. And as understanding the feedback characteristics is the base for further competitive and comparative elements, the respondents should be first made available with informative session where they learn how this different time periods have impact on energy saving before setting up the energy saving program.

In line with this, as game element competition showed extraordinary performance in the optimal MNL model, the group analysis showed that women who already participated in energy saving program preferred goal setting more over competition. This shows the difference in the behavioral attitude of different categories. Therefore, to reach the goal of energy saving, the behavioral attitude of employees need to be changed. And as changing behavior does not take place directly, management of organization should take small steps and focus on attitudes. Firstly, basic insight in the energy consumption pattern should be provided. Then, energy saving potential should be visualized and further more social interaction variables should be added for the best possible outcome.

It is argues that the organizational management can change the behavioral intention of the employees in office environment by implementing energy saving program using smart meter. However, before setting up these energy saving program, first the smart meter environment has to be developed in order to process, analyze and visualize the data. And as observed in the literature, smart meter data is framed under the domain big data, that deals with handling huge amount of information as smart meter generates a message each second. Therefore, before office management can use this data, the underlying challenge is to integrate this data into business process.

In line with this, setting up an energy saving program using the smart meter also need enormous technical support and hence the collaboration with the information technology to configure the

variables studied in this research to deliver the end service in form of energy saving program is essential. IT can carter the organizations with the facilities to design application, analyze and process energy consumption data according to the employees preferences for the variables studied in this research. Therefore, in order to accurately collect and manage this data keeping data security in mind, It-driven business model with proper governance framework is important.

5.3 Theoretical implications

In the field of energy saving and ecological concern, extensive researches has been already done. Specifically for reducing energy consumption, various energy saving program with different theories, stimuli changing behavioral intention of consumers to save energy has already been executed. All these studies did mention what kind of feedback is important, what different social-interaction, normative comparison and game elements are important to ensure energy saving, but majority of them focused on all these aspects separately and with various different approaches. However, this research is an contribution in energy saving literature that combines all these elements into an single energy saving program with altogether different approach of using energy usage information of consumers available through smart meters. Since the invention of smart meters, researchers are continuously striving to optimize energy saving using it especially in the household sector as it is also witnessed in the literature. This research is an attempt to address some of these energy saving measures analyzed before and integrate them into smart meter energy saving application specially catered to encourage employees in office buildings to reduce energy consumption.

Feedback period as aforementioned has been researches earlier with two aspects of direct and indirect feedback with direct feedback having more potential to ensure energy saving according to literature. Although these study did not gave significant output for the feedback period but the MNL coefficients indicates the opposite effect. Respondents preferred more of indirect feedback of receiving energy consumption information daily rather than real time (direct feedback). However because of insignificant results the conclusion cannot be criticized.

Additionally, game elements goal setting, competition and normative comparison has been proved by the previous studies to be very useful in determining energy saving. This study also proved it to be useful but with the approach of smart meter. Additionally, the energy concern question asking respondents participation in any energy saving program undertaken by the management of their office has resulted into getting preferences of the experienced and inexperienced employees and their difference in opinion enhances this study by giving it broader approach. From this bifurcation of male and female respondents having experience and not having experience of energy saving program the difference in behavioral attitude is visible. As male are considered to be more competitive then female, the preferences for female giving more weightage to goal setting to improve own energy saving behavior benefiting themselves and their family (self-efficacy) weighted higher as compared to competing with others to save energy and receiving reward. All these findings can be extensively added to the theoretical background in this filed.

5.4 Discussion

This section comprises of discussion on certain weaknesses and improvements for the research. During the study the attributes that can drive behavioral intention to save energy were extensively studied and carefully incorporated in the study. However, all the variables did not show significant effect. A comparatively large group of respondent or even better distribution of respondents on gender can give a different interpretation of results. As socio demographic literature says female has more energy saving concern than men, it would be interesting to compare the differences in their opinion if they were more or less equally distributed. However, some variables showed different responses, but since the male participation in the survey is two times that of the females, the evaluation of the responses cannot be made firmly.

Setting up the choice experiment for this study was not easy since the approach of energy saving by integrating smart meter data is not widely used before and hence respondents are unaware of it, only 45 respondents out of 193 are aware of what smart meter is which gives the evidence of it. Hence to make respondents realize how the smart meter data can motivate them to save energy using attributes used in the study needed to be properly explained. This resulted into a brief introduction of all the variables along with the graphical and picturesque representation before the start of choice experiment. Attributes in feedback characteristics and other attributes namely comparison, information screen and gamification elements were closely related since based upon what type and period of information they prefer the other attributes would be realized. Due to restriction of the survey length a scenario of every possible combination was not possible and hence few of them were showed and the relation between them was explained in the description. The levels in attributes feedback period did not show any significance which was unexpected indicates that respondents fail to realize the importance of this attribute through the visual shown in description. Although the another possible way was to show the respondents image of the different levels of variables in an alternative during choice experiment instead of the labels of those variables, but this was not feasible since demo survey forwarded to few respondents with image indicated it to be too lengthy and time consuming which would result into respondent losing interest in the survey. After the survey it was realized that in the choice experiment a link of the image along with the label of variable levels for each alternative could have guided the respondents whenever they feel the need to understand it.

The R-square value of the MNL model showed very low goodness of fit with value only 0.06. Although a value between 0.2 to 0.4 is usually said to be good, but 0.1 is also considered acceptable. The purpose of this study can be the reason for this R-square value lower than 1. The studies that takes human behavior into account has relatively lower goodness of fit because the human behavior is difficult to predict than say physical activity (Frost, 2013). But still the coefficient of the attributes can be interpreted and it also showed the expected results extensively.

5.5 Recommendations

With this research, some recommendations are outlined for the stakeholders directly related to the topic to keep investigating in this field. Smart meters are considered as the evolution in smart technology that can bring positive impact in energy saving. Government authority of various nations have undertaken smart meter roll out to make their citizens aware of their energy consumption and learn from it the possible measures to save energy. These rollouts are majorly facilitated for the household as a process of turning to smart grid. Since employees in office organizations are under legal binding of the organization, they cannot target the smart meter roll out to the employees. Therefore, in order to make a complete decentralized system, they should focus on discussion with organization management to search for possible ways to bring organizations under the smart meter roll out as well. This will also contribute incorporation of additional stimuli price differentiation meaning setting up the prices differently for different hours of the day ultimately determining willingness to pay for the organizations. With this binding, the organization can optimize the strategies to shift energy load on off peak hours by making their employees work in different shifts. As this is just a raw idea an extensive research in this domain needs to be done. With this in place, the consumption data of the employees would be analyzed and processes by the energy providers and the management will no more have to focus on this. This will also need proper legal consultation. Also, the energy providers can use the outcome of this study to incorporate it in their current smart meter roll out for the households. The only difference will be the normative comparison, and game elements like goal setting and competition would be with the other households of the neighborhood.

In this study, during the survey, respondents were told to assume that they are divided in teams of 8-15 employees depending on the size and composition of the office staff. However, this was addressed to understand the gist of the research, extensive study as to what number of employees and what combination of employees working on different sectors within an office building should be executed to enhance the energy saving even more. This also applies for the different organizations working in varied sectors since working environment differs with the stream they work on.

As game element competition gained highest preference to determine energy saving, further research on what form of reward should be given to the winning teams to determine intention to save energy excessively should be carried out. Also competition can lead to distraction of employees from work, therefore what level of competition and its degree of intense should also be determined.

For this research some screenshots were shown to the respondents so as to get the idea as how various elements researched in this study be visualized. Bar chart with numbers showing the overview of their team energy consumption related to the attributes were used. Further research should also be executed to discover the best and appealing way to show their consumption.

For the attribute information screens , respondents significantly opted for receiving consumption information on public screen. Therefore, at what locations these screen should be placed to increase their motivation to save energy should be explored.

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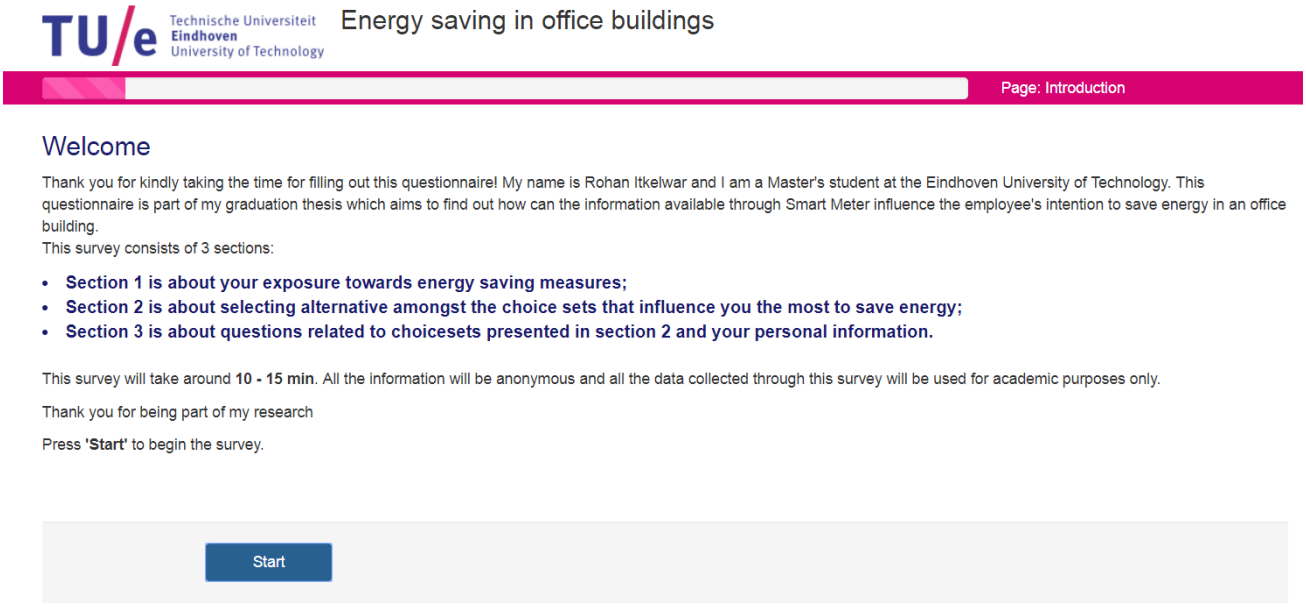
Appendix A

Questionnaire



Technische Universiteit Eindhoven University of Technology

Energy saving in office buildings

Page: Introduction

Welcome

Thank you for kindly taking the time for filling out this questionnaire! My name is Rohan Itkelwar and I am a Master's student at the Eindhoven University of Technology. This questionnaire is part of my graduation thesis which aims to find out how can the information available through Smart Meter influence the employee's intention to save energy in an office building.
This survey consists of 3 sections:

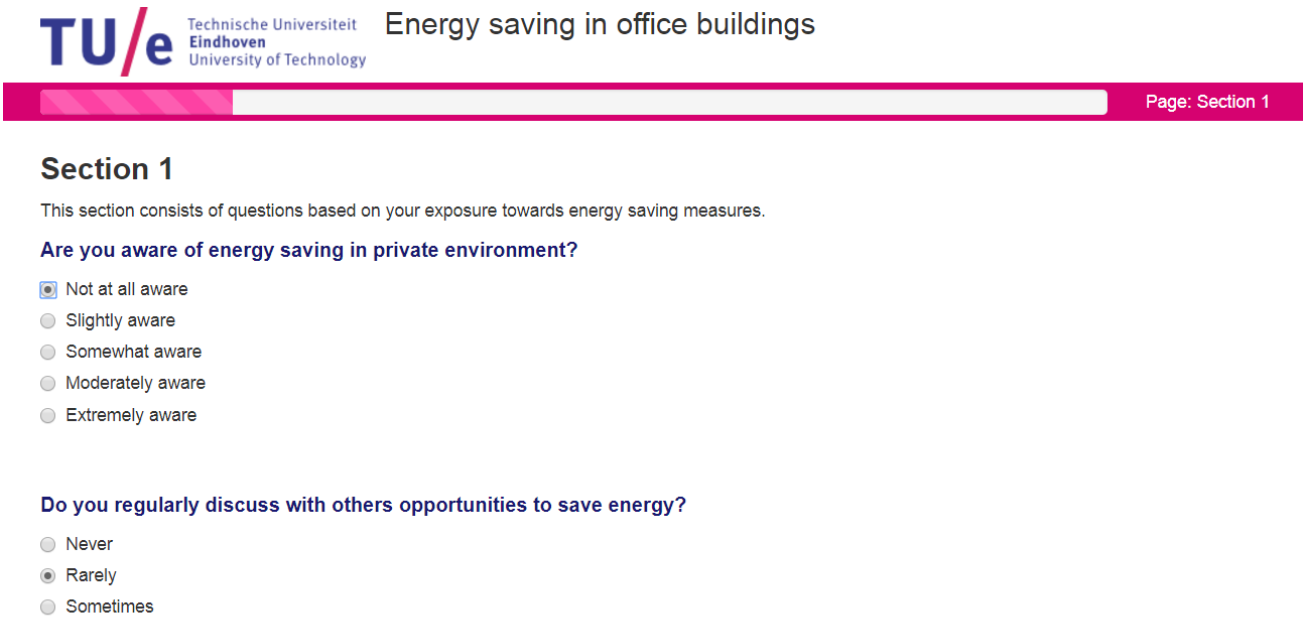
- **Section 1 is about your exposure towards energy saving measures;**
- **Section 2 is about selecting alternative amongst the choice sets that influence you the most to save energy;**
- **Section 3 is about questions related to choicesets presented in section 2 and your personal information.**

This survey will take around **10 - 15 min**. All the information will be anonymous and all the data collected through this survey will be used for academic purposes only.

Thank you for being part of my research

Press **'Start'** to begin the survey.

Start



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Energy saving in office buildings

Page: Section 1

Section 1

This section consists of questions based on your exposure towards energy saving measures.

Are you aware of energy saving in private environment?

- (•) Not at all aware
- ( ) Slightly aware
- ( ) Somewhat aware
- ( ) Moderately aware
- ( ) Extremely aware

Do you regularly discuss with others opportunities to save energy?

- ( ) Never
- (•) Rarely
- ( ) Sometimes
- ( ) Often
- ( ) Always

"If everyone tries to save energy at offices, this will not make a difference to the total energy consumption for the whole city".

- ( ) Totally disagree
- ( ) Disagree
- (•) Neutral
- ( ) Agree
- ( ) Totally agree

Do you perform regular activities at home with the concern towards energy saving?

- ○ Never
- ○ Rarely
- ○ Sometimes
- ◉ Often
- ○ Always

Do you perform activities at office with the concern towards energy saving?

- ○ Never
- ○ Rarely
- ○ Sometimes
- ◉ Often
- ○ Always

Does the management of your office has ever undertaken any energy saving program?

- ◉ Yes
- ○ No

Have you ever heard about "Smart Meter", that can provide you detailed information about your energy usage?

- ○ Yes
- ◉ No

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Page: Section 2

Section 2 (Assume)

Assume that the management of your office has undertaken energy saving program, for which the employees in your office are divided into several groups. The divison of groups is based either upon the number of employees (8-15) in each group or by forming a group of employees on each floor, depending upon the size and composition of employees. For this energy saving program, "Smart meter" is attached to the electric mains of every group so as to get information regarding energy usage of every group.

In this section you will be shown a total of 8 scenarios, each consisting of a table with 2 options of information received through Smart Meter. From these you will be required to select the one which motivates you more to save energy.
In case you don't find any of the options motivating, you will be able to select the option "None of these".

The factors will be divided in the following factor groups:

- **Information characteristics**
- **Social interaction factors**
- **Game elements**

Some important aspects you must consider before making your choice:

- **Next page consists of the complete information regarding every factor and it's option categories. Please read the information carefully to make a good choice.**
- **Also the example question of a scenario is shown.**

Please Click on "Next" **to continue.**

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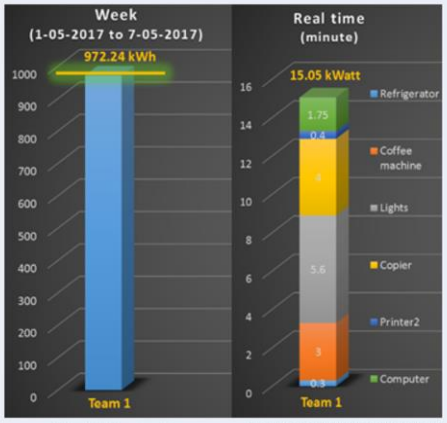
Page: q1

Below you can see description of the factor group 'Information characterisitcs'.

Factors	Option categories	Examples
Feedback type	**Overall information:** Information about energy consumed by all the appliances together, used by your team. **Appliance level information:** Information about energy consumed by each appliance used by your team.	 Overall Appliance level
Feedback period (Information will be provided depending on the feedback type you prefer)	**Daily:** Energy consumption information of the previous day. **Weekly:** Energy consumption information of the previous week. **Monthly:** Energy consumption information of the previous month. **Realtime:** Energy consumption information in real time (every minute).	 Weekly (overall) Real time (Appliance level)

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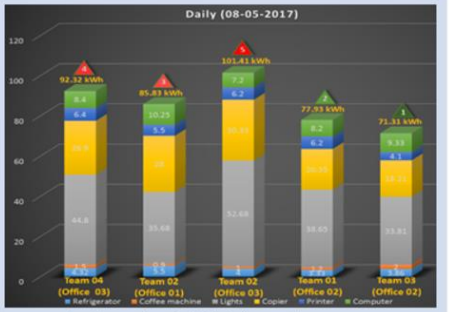
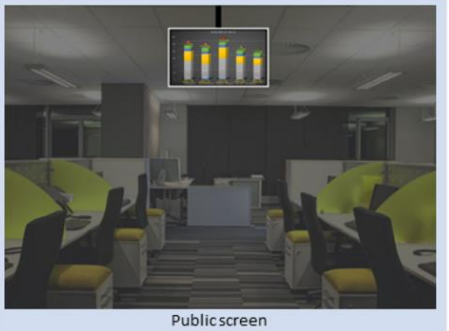
Below you can see description of the factor group 'Social interaction'.

Factors	Option categories	Examples
Comparison (Information will be provided depending on the feedback type and period you prefer)	**Company 's average:** Comparing energy consumption of your team with the average consumption of all the teams within your office.	 Overall - Monthly Information
	Teams within office: Comparing energy consumption of your team with the other teams in your office.	 Appliance level–Real time Information
	Teams outside office: Comparing energy consumption of your team with the teams outside your office participating in energy saving program but similar to your company or department	 Appliance level–Daily Information

Factors	Option categories	Examples
Information screen (The information displayed would be according to your preference for above factors)	**Public screens:** The information mentioned above would be displayed on screens hanged in common areas.	 Public screen

	Personal screens: The information mentioned above would be displayed on your own computer screens.	 Personal screen

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Below you can see description of the factor group 'Game elements'.

Factors	Option categories	Examples
Goal setting (Information will be provided depending on the feedback period you prefer)	You will receive the target depending upon your own team's energy consumption pattern. This target will help you in improving energy saving. **Yes:** If you think this motivate you to save energy. **No:** If you think this doesn't motivate you to save energy.	 Goal setting (Daily)
Competition (Information will be provided depending on the feedback period you prefer)	You will receive the target depending upon your own team's energy consumption pattern. If you achieve this target you will get some **credits**. At the end of energy program the team that scores highest credits will receive **reward**. **Yes:** If you think this motivate you to save energy. **No:** If you think this doesn't motivate you to save energy.	 Competition (Daily)

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Page: Choice_example

This is an example question!

All the factors you have seen on the previous pages are placed together in two different options according to their option categories and you have to select the option that motivates you more to save energy. In case you don't find any of the option motivating you can select the option "None of these".

(Note: Clicking on the dotted line below every factor will show a short description of that factor)

Factor group		Option A	Option B	None of these
Information characteristics	Feedback type	Appliance level information	Overall information	
	Feedback period	Real time	Weekly	
Social Interaction	Comparison	Teams within office	Teams within office	
	Information screen	Public screens	Personal screens	
Game elements	Goal setting	No	No	
	Competition	Yes	No	
Your choice		X	O	O

Click "Next" to begin the choice experiment.

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Page: Choice_Sets

Please select the option that corresponds with your preferences. In case none of the options matches your preferences, please select the option 'None of these'.

Factor group		Option A	Option B	None of these
Information characteristics	Feedback type	Overall information	Overall information	
	Feedback period	Daily	Monthly	
Social Interaction	Comparison	Teams within office	Teams outside office	
	Information screen	Public screens	Personal screens	
Game elements	Goal setting	Yes	Yes	
	Competition	Yes	No	
Your choice		☐	○	○

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Page: Choice_Sets

Please select the option that corresponds with your preferences. In case none of the options matches your preferences, please select the option 'None of these'.

Factor group		Option A	Option B	None of these
Information characteristics	Feedback type	Overall information	Appliance level information	
	Feedback period	Monthly	Weekly	
Social Interaction	Comparison	Teams outside office	Teams outside office	
	Information screen	Personal screens	Public screens	
Game elements	Goal setting	Yes	Yes	
	Competition	No	Yes	
Your choice		☐	○	○

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Page: Choice_Sets

Please select the option that corresponds with your preferences. In case none of the options matches your preferences, please select the option 'None of these'.

Factor group		Option A	Option B	None of these
Information characteristics	Feedback type	Overall information	Overall information	
	Feedback period	Real time	Monthly	
Social Interaction	Comparison	Company's average	Teams outside office	
	Information screen	Public screens	Personal screens	
Game elements	Goal setting	No	Yes	
	Competition	No	No	
Your choice		☐	○	○

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Page: Choice_Sets

Please select the option that corresponds with your preferences. In case none of the options matches your preferences, please select the option 'None of these'.

Factor group		Option A	Option B	None of these
Information characteristics	Feedback type	Overall information	Appliance level information	
	Feedback period	Daily	Daily	
Social Interaction	Comparison	Teams within office	Company's average	
	Information screen	Public screens	Personal screens	
Game elements	Goal setting	Yes	No	
	Competition	Yes	Yes	
Your choice		☐	○	○

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Page: Choice_Sets

Please select the option that corresponds with your preferences. In case none of the options matches your preferences, please select the option 'None of these'.

Factor group		Option A	Option B	None of these
Information characteristics	Feedback type	Appliance level information	Overall information	
	Feedback period	Daily	Monthly	
Social Interaction	Comparison	Company's average	Company's average	
	Information screen	Personal screens	Public screens	
Game elements	Goal setting	No	Yes	
	Competition	Yes	Yes	
Your choice		☐	○	○

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Page: Choice_Sets

Please select the option that corresponds with your preferences. In case none of the options matches your preferences, please select the option 'None of these'.

Factor group		Option A	Option B	None of these
Information characteristics	Feedback type	Overall information	Appliance level information	
	Feedback period	Weekly	Daily	
Social Interaction	Comparison	Teams within office	Teams outside office	
	Information screen	Personal screens	Public screens	
Game elements	Goal setting	No	No	
	Competition	Yes	No	
Your choice		☐	○	○

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Page: Choice_Sets

Please select the option that corresponds with your preferences. In case none of the options matches your preferences, please select the option 'None of these'.

Factor group		Option A	Option B	None of these
Information characteristics	Feedback type	Appliance level information	Appliance level information	
	Feedback period	Monthly	Daily	
Social Interaction	Comparison	Teams within office	Teams outside office	
	Information screen	Public screens	Public screens	
Game elements	Goal setting	No	No	
	Competition	No	No	
Your choice		☐	○	○

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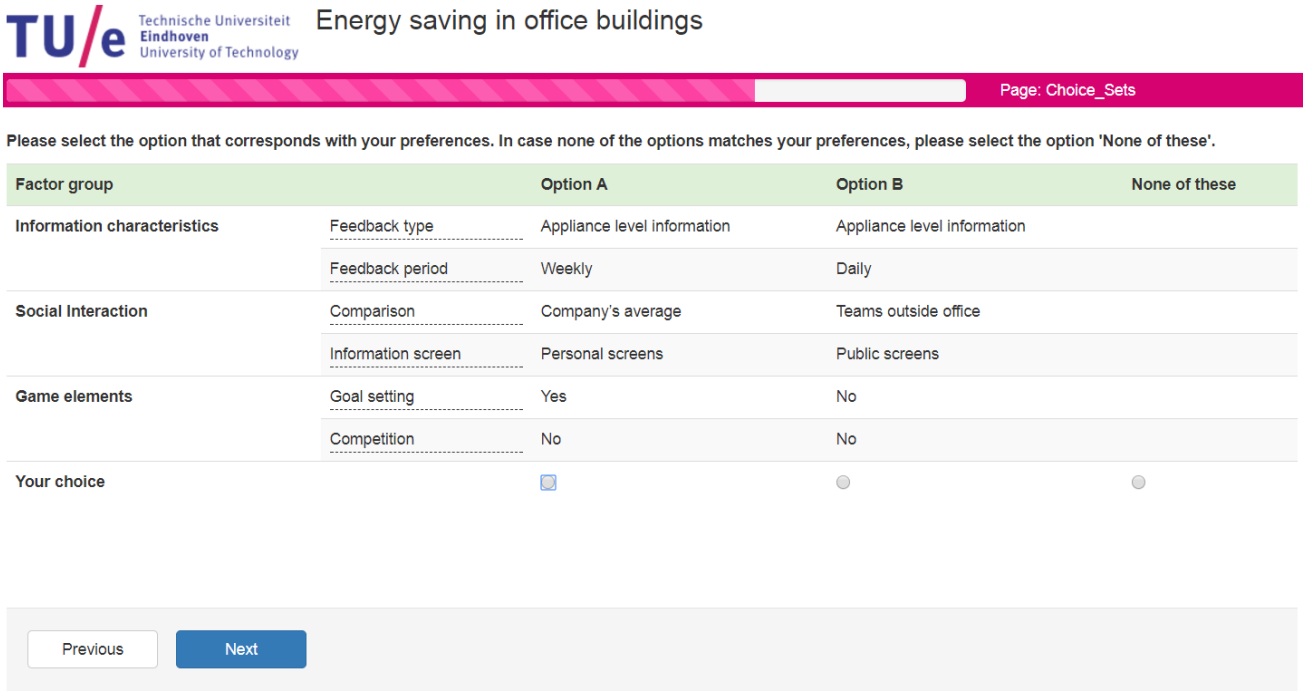

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Page: Choice_Sets

Please select the option that corresponds with your preferences. In case none of the options matches your preferences, please select the option 'None of these'.

Factor group		Option A	Option B	None of these
Information characteristics	Feedback type	Appliance level information	Appliance level information	
	Feedback period	Weekly	Daily	
Social Interaction	Comparison	Company's average	Teams outside office	
	Information screen	Personal screens	Public screens	
Game elements	Goal setting	Yes	No	
	Competition	No	No	
Your choice		☐	○	○

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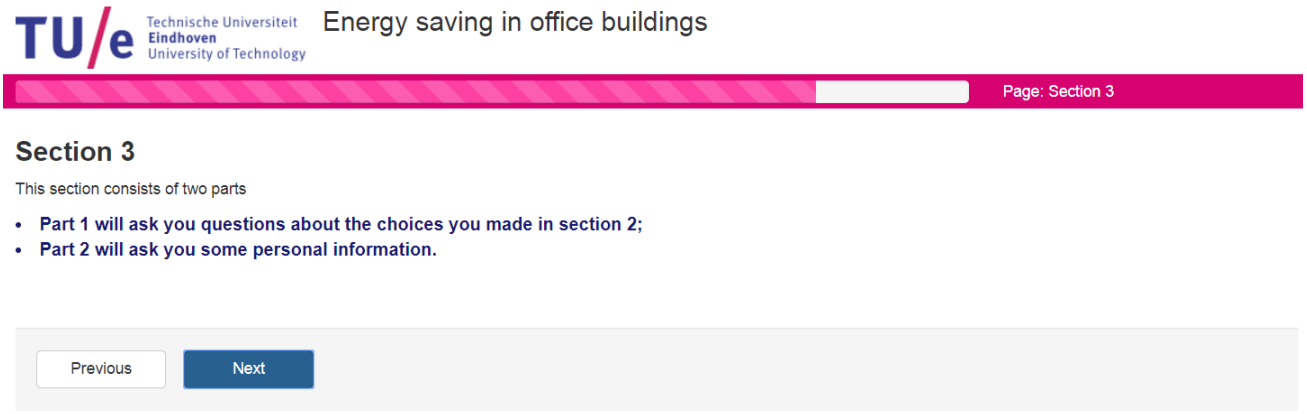

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Page: Section 3

Section 3

This section consists of two parts

- **Part 1 will ask you questions about the choices you made in section 2;**
- **Part 2 will ask you some personal information.**

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Energy saving in office buildings

Page: Part 1

Part 1

How important is it to know the electricity consumed by single appliances (in addition to the total electricity consumed)?

- Very unimportant
- Unimportant
- Neutral
- Important
- Very Important

How important is it to know the electricity consumed in real time?

- Very unimportant
- Unimportant
- Neutral
- Important
- Very Important

How important is it to know the electricity consumed per month?

- Very unimportant
- Unimportant
- Neutral
- Important
- Very Important

How important is it to compare your team's electricity consumption to other similar teams or to the office's average?

- Very unimportant
- Unimportant
- Neutral
- Important
- Very Important

How important is it to have a target level for electricity consumption (the goals is not to consume more)?

- Very unimportant
- Unimportant
- Neutral
- Important
- Very Important

How important is it to be able to collect points for reducing energy consumption (the more point, the higher your social status and the chances to win reward)?

- Very unimportant
- Unimportant
- Neutral
- Important
- Very Important

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Part 2

What is your gender?

- Male
- Female

What is your age group?

- 18 to 24 years
- 25 to 34 years
- 35 to 44 years
- 45 to 54 years
- 55 to 64 years
- Age 65 or older

What is the highest level of your education?

- Trade/technical/vocational training
- Associate degree
- Bachelor's degree
- Master's degree
- Professional degree
- Doctorate degree
- Other

Which of the following categories best describes your primarily area of employment (regardless of your actual position)?

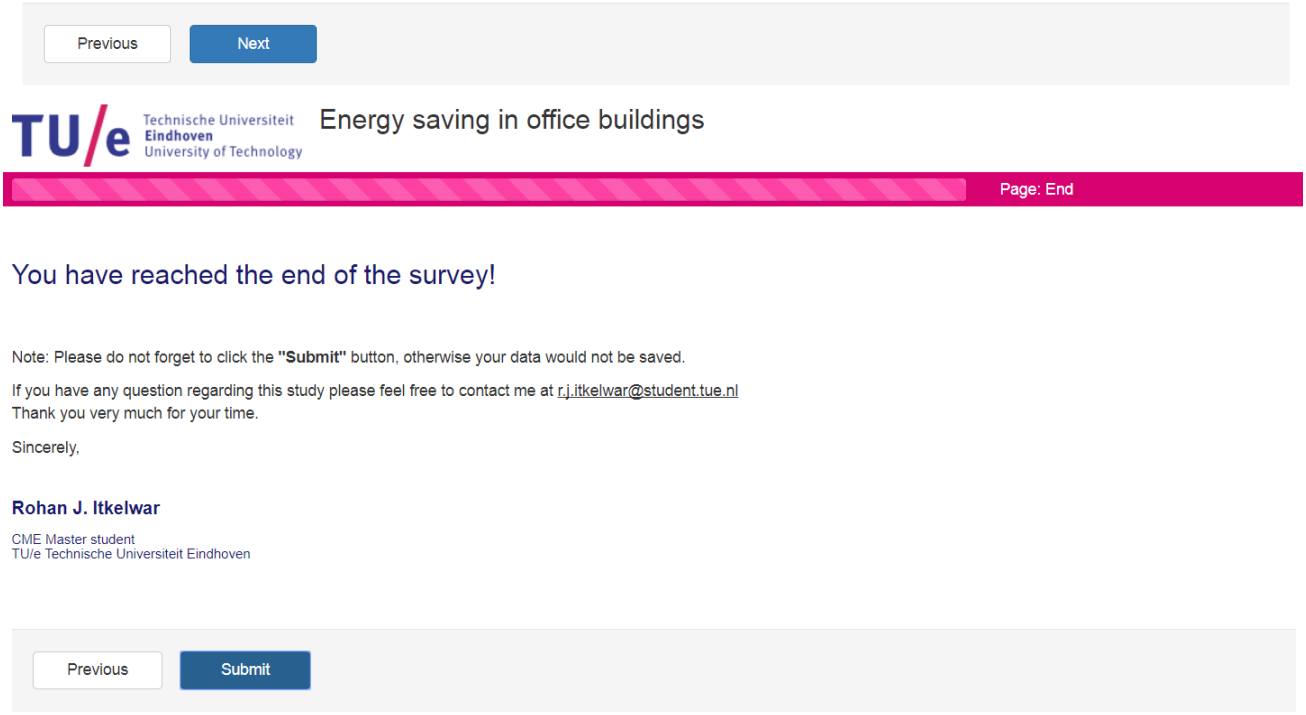
Make a choice

Which geographical region you belong to?

- Asia
- Central America
- European Union
- Middle East
- North America
- Oceania
- South America
- The Carribean
- United Kingdom
- Africa

Which geographical region you are currently working at?

- Asia
- Central America
- European Union
- Middle East
- North America
- Oceania
- South America
- The Carribean
- United Kingdom
- Africa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Page: End
You have reached the end of the survey!
Note: Please do not forget to click the "Submit" button, otherwise your data would not be saved.
If you have any question regarding this study please feel free to contact me at r.j.itkelwar@student.tue.nl
Thank you very much for your time.
Sincerely,
Rohan J. Itkelwar
CME Master student
TU/e Technische Universiteit Eindhoven
Previous
Submit

Appendix B
Original respondents groups

Respondent group based on age

Age group	18-24	25-34	35-44	45-54	55-64	>65
#	47	124	14	5	2	1
%	24.35%	64.24%	7.25%	2.59%	1.03%	0.54%

Respondent group based on level of education

Education	Trade/technical/vocational training	Associate degree	Bachelor's degree	Master's degree	Professional degree	Doctorate degree	others
#	1	2	89	82	11	5	3
%	0.51%	1.03%	46.11%	42.48%	5.69%	2.59%	1.59%

Respondent group based on nationality and job location

Geographical Region	Nationality (#)	Nationality (%)	Job location (#)	Job location (%)
Asia	155	80.31%	125	64.77%
Central America	2	1.04%	2	1.04%
European Union	26	13.47%	52	26.94%
Middle East	1	0.52%	2	1.04%
North America	5	2.59%	9	4.66%
Oceanic	-	-	2	1.04%
South America	1	0.52%	-	-
The Caribbean	-	-	1	0.52%
United Kingdom	1	0.52%	-	-
Africa	2	1.04%	-	-

Respondent group based on job profile

Job profile	#	%
Agriculture, Forestry, Fishing, or Hunting	-	-
Architecture	44	22.80%
Broadcasting	-	-
Education - College, University, or Adult	19	9.84%
Education - Other	7	3.63%
Construction	18	9.33%
Finance and Insurance	4	2.07%
Government and Public Administration	4	2.07%
Health Care and Social Assistance	16	8.29%
Hotel and Food Services	2	1.04%
Information - Services and Data	11	5.70%
Information - Other	3	1.55%
Processing	2	1.04%
Legal Services	1	0.52%
Manufacturing - Computer and Electronics	2	1.04%
Manufacturing - Other	11	5.70%
Mining	-	-
Publishing	-	-
Real Estate, Rental, or Leasing	4	2.07%
Scientific or Technical Services	7	3.63%
Software	21	10.88%
Telecommunications	3	1.55%
Other	14	7.25%

Appendix C

MNL model (optimal model)

```
|-> DISCRETECHOICE
    ;Lhs=Choice
    ;CHOICES=PA,PB,None
    ;Rhs=Const,F_TYPE,PRID1,PRID2,PRID3,COMPR1,COMPR2,SCRN,GOAL,COMPTN
    $
Normal exit:   6 iterations. Status=0, F=    1306.085

--------------------------------------------------------------------------------
Discrete choice (multinomial logit) model
Dependent variable                Choice
Log likelihood function     -1306.08533
Estimation based on N =   1544, K =  10
Inf.Cr.AIC  =   2632.2 AIC/N =    1.705
Model estimated: Jun 16, 2017, 14:55:30
R2=1-LogL/LogL* Log-L fncn R-sqrd R2Adj
Constants only  -1388.5412  .0594 .0563
Response data are given as ind. choices
Number of obs.=  1544, skipped    0 obs
--------+-----------------------------------------------------------------------
        |                 Standard            Prob.      95% Confidence
  CHOICE|  Coefficient       Error       z    |z|>Z*         Interval
--------+-----------------------------------------------------------------------
   CONST|    1.82110***      .09938    18.33  .0000     1.62632   2.01588
  F_TYPE|     .12913***      .03688     3.50  .0005      .05685    .20140
   PRID1|    -.04305         .06355     -.68  .4981     -.16762    .08151
   PRID2|     .07662         .06327     1.21  .2259     -.04739    .20064
   PRID3|    -.09157         .06354    -1.44  .1496     -.21611    .03297
  COMPR1|     .11982**       .04929     2.43  .0151      .02322    .21643
  COMPR2|    -.07934         .05864    -1.35  .1760     -.19427    .03558
    SCRN|     .14093***      .03718     3.79  .0002      .06807    .21379
    GOAL|     .24394***      .03736     6.53  .0000      .17072    .31717
  COMPTN|     .37073***      .03798     9.76  .0000      .29628    .44517
--------+-----------------------------------------------------------------------
Note: ***, **, * ==>  Significance at 1%, 5%, 10% level.
--------------------------------------------------------------------------------
```

Appendix D

Group 1 :Male, participated in energy saving program

```
|-> IMPORT;FILE="C:\Users\s151937\Desktop\group analysis\ES_Yes_Male.xls"$
|-> DISCRETECHOICE
    ;Lhs=Choice
    ;CHOICES=PA,PB,None
    ;Rhs=One,F_TYPE,PRID1,PRID2,PRID3,COMPR1,COMPR2,SCRN,GOAL,COMPTN,
    $
Normal exit:   5 iterations. Status=0, F=    377.9010

--------------------------------------------------------------------------------
Discrete choice (multinomial logit) model
Dependent variable                Choice
Log likelihood function      -377.90103
Estimation based on N =    448, K =  11
Inf.Cr.AIC  =    777.8 AIC/N =    1.736
Model estimated: Jun 21, 2017, 14:35:37
R2=1-LogL/LogL* Log-L fncn R-sqrd R2Adj
Constants only   -407.8142  .0734 .0618
Chi-squared[ 9]           =     59.82640
Prob [ chi squared > value ] =   .00000
Response data are given as ind. choices
Number of obs.=   448, skipped    0 obs
--------+-----------------------------------------------------------------------
        |                 Standard            Prob.      95% Confidence
  CHOICE|  Coefficient       Error       z    |z|>Z*         Interval
--------+-----------------------------------------------------------------------
  F_TYPE|     .14669**       .07232     2.03  .0425      .00494    .28843
   PRID1|     .12882         .12024     1.07  .2840     -.10685    .36449
   PRID2|     .00346         .12169      .03  .9773     -.23504    .24196
   PRID3|    -.20058*        .11865    -1.69  .0909     -.43314    .03197
  COMPR1|     .19195**       .09460     2.03  .0425      .00652    .37737
  COMPR2|    -.00394         .10905     -.04  .9712     -.21767    .20979
    SCRN|     .16857**       .07252     2.32  .0201      .02644    .31070
    GOAL|     .15680**       .06922     2.27  .0235      .02112    .29247
  COMPTN|     .41910***      .07305     5.74  .0000      .27593    .56227
    A_PA|    1.80723***      .18240     9.91  .0000     1.44973   2.16473
    A_PB|    1.56233***      .18706     8.35  .0000     1.19570   1.92897
--------+-----------------------------------------------------------------------
Note: ***, **, * ==>  Significance at 1%, 5%, 10% level.
--------------------------------------------------------------------------------
```

Group 2: Male, not participated in energy saving program

```
|-> IMPORT;FILE="C:\Users\s151937\Desktop\group analysis\ES_No_Male.xls"$
|-> DISCRETECHOICE
    ;Lhs=Choice
    ;CHOICES=PA,PB,None
    ;Rhs=One,F_TYPE,PRID1,PRID2,PRID3,COMPR1,COMPR2,SCRN,GOAL,COMPTN,
    $
Normal exit:   5 iterations. Status=0, F=    460.2129

--------------------------------------------------------------------------------
Discrete choice (multinomial logit) model
Dependent variable                Choice
Log likelihood function      -460.21288
Estimation based on N =    584, K =  11
Inf.Cr.AIC  =    942.4 AIC/N =    1.614
Model estimated: Jun 21, 2017, 14:16:56
```

```
R2=1-LogL/LogL* Log-L fncn R-sqrd R2Adj
Constants only   -502.4583  .0841 .0754
Chi-squared[ 9]          =     84.49081
Prob [ chi squared > value ] =   .00000
Response data are given as ind. choices
Number of obs.=   584, skipped    0 obs
--------+------------------------------------------------------------------
        |                 Standard            Prob.      95% Confidence
  CHOICE|  Coefficient       Error       z    |z|>Z*         Interval
--------+------------------------------------------------------------------
  F_TYPE|     .17825***      .06070     2.94  .0033      .05929    .29721
   PRID1|    -.08938         .10707     -.83  .4038     -.29925    .12048
   PRID2|     .08884         .10591      .84  .4016     -.11874    .29641
   PRID3|    -.14522         .10715    -1.36  .1754     -.35523    .06480
  COMPR1|     .15471*        .08324     1.86  .0631     -.00844    .31786
  COMPR2|    -.08898         .10181     -.87  .3821     -.28852    .11056
    SCRN|     .13648**       .06123     2.23  .0258      .01646    .25650
    GOAL|     .33934***      .06344     5.35  .0000      .21500    .46368
  COMPTN|     .38878***      .06306     6.17  .0000      .26519    .51238
    A_PA|    2.28104***      .18910    12.06  .0000     1.91040   2.65168
    A_PB|    1.95744***      .19081    10.26  .0000     1.58345   2.33142
--------+------------------------------------------------------------------
Note: ***, **, * ==>  Significance at 1%, 5%, 10% level.
-----------------------------------------------------------------------------
```

Group 3 : Female, participated in energy saving program

```
|-> IMPORT;FILE="C:\Users\s151937\Desktop\group analysis\ES_Yes_Female.xls"$
|-> DISCRETECHOICE
    ;Lhs=Choice
    ;CHOICES=PA,PB,None
    ;Rhs=One,F_TYPE,PRID1,PRID2,PRID3,COMPR1,COMPR2,SCRN,GOAL,COMPTN,
    $
Normal exit:   4 iterations. Status=0, F=    233.3193

-----------------------------------------------------------------------------
Discrete choice (multinomial logit) model
Dependent variable                Choice
Log likelihood function      -233.31930
Estimation based on N =    264, K =  11
Inf.Cr.AIC  =    488.6 AIC/N =    1.851
Model estimated: Jun 21, 2017, 14:37:21
R2=1-LogL/LogL* Log-L fncn R-sqrd R2Adj
Constants only   -242.9370  .0396 .0192
Chi-squared[ 9]          =     19.23541
Prob [ chi squared > value ] =   .02326
Response data are given as ind. choices
Number of obs.=   264, skipped    0 obs
--------+------------------------------------------------------------------
        |                 Standard            Prob.      95% Confidence
  CHOICE|  Coefficient       Error       z    |z|>Z*         Interval
--------+------------------------------------------------------------------
  F_TYPE|     .07205         .08982      .80  .4224     -.10399    .24808
   PRID1|    -.05813         .14663     -.40  .6918     -.34553    .22927
   PRID2|     .20080         .14926     1.35  .1785     -.09174    .49334
   PRID3|    -.07655         .15649     -.49  .6247     -.38327    .23017
  COMPR1|     .02961         .11345      .26  .7941     -.19274    .25196
  COMPR2|    -.27366**        .13444    -2.04  .0418     -.53716   -.01016
    SCRN|     .07972         .08885      .90  .3696     -.09444    .25387
    GOAL|     .24581***      .08980     2.74  .0062      .06979    .42182
  COMPTN|     .18169**       .08818     2.06  .0394      .00886    .35452
    A_PA|    1.74894***      .23362     7.49  .0000     1.29106   2.20682
    A_PB|    1.66470***      .23764     7.01  .0000     1.19895   2.13046
--------+------------------------------------------------------------------
```

```
Note: ***, **, * ==>  Significance at 1%, 5%, 10% level.
-------------------------------------------------------------------------------
```

Group 4: Female, not participated in energy saving program

```
|-> IMPORT;FILE="C:\Users\s151937\Desktop\group analysis\ES_No_Female.xls"$
|-> DISCRETECHOICE
    ;Lhs=Choice
    ;CHOICES=PA,PB,None
    ;Rhs=One,F_TYPE,PRID1,PRID2,PRID3,COMPR1,COMPR2,SCRN,GOAL,COMPTN,
    $
Normal exit:   5 iterations. Status=0, F=    208.0813

-------------------------------------------------------------------------------
Discrete choice (multinomial logit) model
Dependent variable                Choice
Log likelihood function       -208.08132
Estimation based on N =    248, K =  11
Inf.Cr.AIC  =    438.2 AIC/N =    1.767
Model estimated: Jun 21, 2017, 14:18:41
R2=1-LogL/LogL* Log-L fncn R-sqrd R2Adj
Constants only   -230.8581  .0987 .0782
Chi-squared[ 9]           =     45.55355
Prob [ chi squared > value ] =   .00000
Response data are given as ind. choices
Number of obs.=   248, skipped    0 obs
--------+----------------------------------------------------------------------
        |                 Standard            Prob.      95% Confidence
  CHOICE|  Coefficient       Error       z    |z|>Z*         Interval
--------+----------------------------------------------------------------------
  F_TYPE|     .12457         .09259     1.35  .1785     -.05691    .30604
   PRID1|    -.37032**       .17272    -2.14  .0320     -.70884   -.03179
   PRID2|     .02914         .15985      .18  .8554     -.28417    .34244
   PRID3|     .23659         .16267     1.45  .1458     -.08223    .55542
  COMPR1|    -.00771         .13292     -.06  .9538     -.26823    .25282
  COMPR2|     .00387         .15308      .03  .9798     -.29615    .30389
    SCRN|     .19863**       .09694     2.05  .0405      .00863    .38863
    GOAL|     .23461**       .10059     2.33  .0197      .03747    .43175
  COMPTN|     .51336***      .10389     4.94  .0000      .30974    .71698
    A_PA|    1.55860***      .24161     6.45  .0000     1.08505   2.03216
    A_PB|    1.57691***      .23990     6.57  .0000     1.10672   2.04709
--------+----------------------------------------------------------------------
Note: ***, **, * ==>  Significance at 1%, 5%, 10% level.
-------------------------------------------------------------------------------
```

Appendix E

RP Logit

```
|-> RPLOGIT
    ;Lhs=Choice
    ;CHOICES=PA,PB,None
    ;Rhs=Const,F_TYPE,PRID1,PRID2,PRID3,COMPR1,COMPR2,SCRN,GOAL,COMPTN,

;FCN=Const(N),F_TYPE(N),PRID1(N),PRID2(N),PRID3(N),COMPR1(N),COMPR2(N),SCRN(N),GOAL(N
),COMPTN(N)
    ;pds=pds
    ;alg=bfgs
    ;halton
    ;pts=1000
    $

Normal exit:  40 iterations. Status=0, F=    1264.452

--------------------------------------------------------------------------------
Random Parameters Logit Model
Dependent variable                CHOICE
Log likelihood function     -1264.45196
Restricted log likelihood   -1696.25737
Chi squared [  20 d.f.]       863.61082
Significance level              .00000
McFadden Pseudo R-squared      .2545636
Estimation based on N =   1544, K =  20
Inf.Cr.AIC  =   2568.9 AIC/N =    1.664
Model estimated: Jun 21, 2017, 03:03:42
R2=1-LogL/LogL* Log-L fncn R-sqrd R2Adj
No coefficients -1696.2574  .2546 .2497
Constants only  -1388.5412  .0894 .0834
At start values -1306.0853  .0319 .0256
Response data are given as ind. choices
Replications for simulated probs. =1000
Used Halton sequences in simulations.
RPL model with panel has     193 groups
Variable number of obs./group =PDS
Number of obs.=  1544, skipped    0 obs
--------+-----------------------------------------------------------------------
        |                 Standard            Prob.      95% Confidence
  CHOICE|  Coefficient       Error       z    |z|>Z*         Interval
--------+-----------------------------------------------------------------------
        |Random parameters in utility functions
   CONST|    2.62372***      .24104    10.88  .0000     2.15128   3.09616
  F_TYPE|     .15846***      .04937     3.21  .0013      .06168    .25523
   PRID1|    -.05122         .07573     -.68  .4988     -.19964    .09721
   PRID2|     .09304         .07594     1.23  .2205     -.05579    .24187
   PRID3|    -.10111         .07534    -1.34  .1796     -.24878    .04655
  COMPR1|     .15965***      .05965     2.68  .0074      .04275    .27656
  COMPR2|    -.08946         .07810    -1.15  .2521     -.24253    .06362
    SCRN|     .18999***      .05393     3.52  .0004      .08430    .29569
    GOAL|     .28720***      .05126     5.60  .0000      .18673    .38767
  COMPTN|     .46835***      .05652     8.29  .0000      .35757    .57914
        |Distns. of RPs. Std.Devs or limits of triangular
 NsCONST|    1.50220***      .21483     6.99  .0000     1.08113   1.92327
NsF_TYPE|     .30056***      .08900     3.38  .0007      .12613    .47500
 NsPRID1|     .06296         .50038      .13  .8999     -.91777   1.04369
 NsPRID2|     .15017         .25770      .58  .5601     -.35491    .65525
 NsPRID3|     .07942         .26018      .31  .7602     -.43051    .58936
NsCOMPR1|     .06995         .22704      .31  .7580     -.37505    .51494
```

```
NsCOMPR2|     .47648***      .12271     3.88  .0001      .23596    .71699
  NsSCRN|     .38250***      .08226     4.65  .0000      .22128    .54373
  NsGOAL|     .30484***      .08866     3.44  .0006      .13108    .47861
NsCOMPTN|     .33772***      .08195     4.12  .0000      .17710    .49834
--------+-------------------------------------------------------------------
Note: ***, **, * ==>  Significance at 1%, 5%, 10% level.
-------------------------------------------------------------------------
```