Høgskolen i Østfold

MASTER THESIS

Designing for user confidence in the evolving age of energy and smart houses

Katarina Larsen Olsen

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Department of computer science

ABSTRACT

Keywords: Smart house, energy management, business intelligence, behaviour change, user confidence.

Smart houses, smart grid, smart metering are words that is getting more and more popular, however there is a problem that the smart house users are not acknowledged by the developers. This thesis introduces a set of guidelines for smart house developer and an energy management method for the users, and the aim is that the latter shall encourage the user to change their behaviour toward energy as well as empowering them and providing more control. By empowering the users, the idea is that the users will become more confident and with that overcome the barriers identified with smart house adoption. Results from the data collected during the literature review and own research showed that there is a need for acknowledging the users and a need for multidisciplinary research and researchers in order to address the field of behaviour change. Among the lessons learned is that most of the conventional users does not know where they use energy and how much and that the users need help in identifying where they waste energy, however they are sceptical towards implementing smart house technology.

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1 INTRODUCTION

> *"The world is changed. I feel it in the water. I feel it in the earth. I smell it in the air.*
> (Jackson, 2001).

The quote above is from the motion picture the Fellowship of the ring, I believe that it describes what has happened in the world, and what is to come, regarding energy related matters. In Europe, the electricity system is rapidly developing and the demand for more and more energy increases with the ever-increasing number of inhabitants of the earth. This has led to an increase in production from renewable energy sources, smart houses and other smart appliances. Across Europe, the smart concept is developing, and developing rapidly. However, in this thesis the focus regarding the smart concept will be revolving around Norway.

The Norwegian energy consumption is of one of the highest per inhabitant in the world, and we are so fortunate that we have an advantage when it comes to renewable energy sources. Renewable energy in combination with smart house technology has been a research area for several years, and for years to come. One problem with smart house technology is that the consumers have been reluctant to adopt it, there are social barriers to overcome, one reason for this is because the developers of smart house technology has focused on the technology aspect as shown in the systematic literature review in chapter 2**.** A smart house solution will provide the consumers with the ability to control their electrical installations and more important control the energy usage. However, the problem is; how can the consumers adopt this concept when the literature review enclosed in appendix 1 and the systematic literature review inspired by (Kitchenham et al., 2007) in chapter 2 shows, it is developed with the technology in focus not the user. This is the area that this thesis aims at enlighten, with the use of business intelligence and energy management and behaviour change.

The amount of research is excessive and there are no indications that the smart house concept is something that will lose its popularity in the near future. A search in a search engine shows how popular this subject is, however one major problem is that it seems that "everyone" have their own solution and system regarding smart houses. As of today there is not one common standard to use for achieving a connected home, one reason can be the rapid technology development. There are a variety of home automation protocols, and an even greater variation regarding smart appliances. (Kastrenakes, 2014). If one wants to have a smart house where the appliances talk together and with other devices, for the time being one have to decide on what home automation protocol to use and from what manufacturer to buy appliances from. If one just buys different brands of appliances, it is not likely that they will "talk" together. The need for one way for appliances to talk together is crucial, a standard like Wi-Fi for example (Kastrenakes, 2014). Therefore, when it comes to smart houses and standards the problem is not the lack of standards; rather it is too many standards. All of them dealing with different problems and sometimes overlapping and competing and making it more difficult for the consumers to adopt the concept.

In November 2015, the European Telecommunications Standards Institute (ETSI) proposed a standard for machine-to-machine architecture called Smart Appliances Reference Ontology (SAREF). SAREF creates a new reference language for energy related data and allows all appliances to exchange energy related information. (The European Telecommunications Standards Institute (ETSI), 2015). This part of the smart house concept is worth mentioning because one will not get a good concept if these problems is not addressed.

However, in this thesis the focus will be from the consumer's point of view. Nevertheless, as stated by (Kastrenakes, 2014) it is not likely that there will be one standard regarding smart houses/appliances and one standard alone might not meet the entire need of the market (Ectors et al., 2015).

The smart house and home automation concept is not a new concept, even though one might think so. With the invention of electrically powered appliances and the introduction of telephones in houses, one might say the home automation era started. (Hendricks, 2014). The first ideas were just that ideas, the technology to make home automation possible lacked. Despite of this, home automation has been widely used in science fiction movies (Back to the future http://www.backtothefuture.com/) and books (There will be soft Rains (Bradbury, 1950). It was not until the 1960's and the creation of the "Electronic Computing Home Operator" (ECHO IV) that home automation as we know it started (Spicer, 2000). However, it was not until the 1990's that the concept rapidly developed.

When smart houses are mentioned today, almost everyone automatically reflects upon the technology in use and how that technology can be beneficial to them. Most of the consumers wants to know how the technology can make their house "smart", how to save money and what appliances can be automated. The technology commonly includes sensors, network, some form for intelligent system and visualization. With the increase of mobile devices in the last years, these are commonly presented as a management tool. Research over the past years (as shown in chapter 2) shows that the smart house concept itself might not be sufficient when it comes to energy saving. The smart house concept was originally developed with focus on improving and helping the consumers in their daily life, security and energy saving. In the latter years, the focus has expanded into healthcare, assisting people with disabilities and the elderly. (Chan, Estève, Escriba, & Campo, 2008). With the smart house concept and its associated technology affecting many aspects of our lives how can the users obtain control?

The term energy management has a number of different meanings, and it involves several different processes. Energy management has been a buzzword in offices and large buildings for a period however, it is not until the last years it has gain popularity in residential homes. Nevertheless, energy management often occurs in hindsight, when the energy bill arrives. The bill itself does not provide information regarding energy usage. Because of that, homeowners take a "driving in the dark" approach when it comes to reducing energy consumption (BizEE software Ltd, n.d.).

Business intelligence (BI) is an umbrella term that includes the tools, applications and best practise used for gaining access, for analysing information with the intention of improve and optimize decisions and performance (Gartner Research, n.d.). By borrowing the BI philosophy and combining this with the smart house concept and energy management, the goal is not to reinvent the wheel but to make improvement regarding the latter with the consumer in focus.

The term behaviour change refers to how a person acts or responds to different stimuli. When one refers to behaviour change it is often believed that changing some elements regarding the behaviour will lead to change. This in most cases will lead to short-term change, because the underlying fundament is the same. To be able to change behaviour, the attitude needs to be changed first. An attitude change is a modification of a person's general evaluative observation of a stimulus, for example a child copying the parent's attitude towards energy saving. It is the underlying attitude that forms the behaviour; this is what makes us individuals (Cacioppo, Petty, & Crites, 1994).

Based upon the fact that every person has different attitude this is also why forced change have a low chance of success. For an individual to permanent change their behaviour the underlying attitude needs to be altered.

The goal is to combine research on these areas and present a solution with the consumer as main priority.

1.1 MOTIVATION

One of the main motivations for doing this project is because I want to provide a "new" way for consumers to think about energy saving and usage. The aim is not to discard the technology but to give the consumers an alternative way of thinking about and using the smart house technology and concept.

Another motivation for doing this project is based on the bachelor thesis I worked on during the spring of 2014. The thesis was aimed towards Open Automated Demand Response (OpenADR), a technology used in the energy market for reducing electricity usage in periods of high demand. In this thesis it was discovered that the user behaviour plays a big role when it comes to energy saving. The research showed that manual Demand Response only worked for a short period, and then the user would go back to their old habits and energy usage patterns. Based upon that I believe that there are other methods needed when it comes to manual energy savings. The latter mentioned thesis also showed that Automated Demand Response (ADR) have a greater potential regarding saving and reducing of electricity usage, nevertheless ADR requires a two-way communication (smart meters for example) and it requires that the consumer abandons control over their energy usage.

Our research regarding OpenADR showed that if it were combined with smart meters it would provide several advantages, nevertheless that would require the consumer to abandon even more control in their own home.

From an academic point of view there is extensive research regarding smart house technology, energy saving, developing and implementing. However, this is only one side needed for smart houses to work; one aspect I found often left out is humans. There is limited amount of research on the human aspect when it comes to efficient energy management. Which makes this project covering a relatively little researched ground.

In this project, I want to research how the consumer can obtain better energy management without abandoning most of the control and if there is a way to encourage the consumers to change their behaviour on their premises. When it comes to computer science, it is interesting to explore how the human factor can influence a smart house concept when the humans are in focus and not the technology. It is also interesting to explore how such solutions can be designed and how this can potentially can provide value for future projects.

1.2 Research Question

With the ever-increasing amount of smart house appliances/devices, smart devices, applications for every imaginable need, the consumer is showered with possibilities. The opportunities promoted by the manufactures and producers can seem promising, however do they encourage consumers to efficient energy management or is it just another hype. How can the consumers be persuaded into saving energy for example, when the focus from the manufactures side is on the technology. This is something I will look more into by looking at the smart house concept from the consumer's point of view with the use of different methods and techniques.

In this project, my overall research questions are:

> "In what way can the smart (in) house concept in combination with business intelligence contribute to energy management on a higher level among the consumers?"
>
> "How can such an initiative encourage behaviour change among the consumers? "

To be able to discuss this, I will divide the research questions into sub questions:

- How can business intelligence be used for making the users more aware over their daily energy management?
- How can energy management be used to persuade the users towards behaviour change?

1.3 Method

The concept in this thesis has grown over a period. It started out with a systematic literature review in the course "Selected Topic" the autumn of 2015 this is described in more detail in appendix 1. Based upon this review the research questions was developed. The below mentioned methods have been used in this thesis. These are more described in chapter 3.

- Systematic literature review
- Participatory design Workshop
- Interviews and survey
- Development of use case and activity diagram
- Analysis of findings

1.4 Limitations

Behaviour change is a field that stretches from psychology to economy, and there are concepts what will not be covered in this thesis. Because it is such a vast area, I will only focus on what I think is most important for this thesis. To address other concepts will be out of scope.

Energy management as terminology that can mean different thing depending on the context. In this thesis energy management referrers to energy consume and energy saving in residential houses.

Business intelligence is a large field which consist of several components, in this thesis business intelligence will be addressed on a higher level of abstraction and not at the technical level.

1.5 REPORT OUTLINE

Chapter 2 provides more background information and details regarding the smart house concept, business intelligence, behaviour change and energy management and how previous research have reflected on these areas.

Chapter 3 describes the methods used. How the data/information is collected and analysed.

Chapter 4 describes the analysis of the research performed.

Chapter 5 describes the proposed guidelines and method, based on previous research derived from the literature and chapter 4.

Chapter 6 describes the results of the research.

Chapter 7 provides the discussion regarding whether or not the problem can be solved using my suggested approach.

Chapter 8 presents the conclusion of the thesis as well as suggestions for future work.

2 RELATED WORK

This part of the report will serve as an introduction to the project. The focus will be on research topic, related work and serve as an introduction to the different areas this thesis focuses on. *It will also describe how the presented research relates to this thesis.*

2.1 RESEARCH TOPIC

A quick search on the internet shows that there are several solutions for smart houses and some of them have been on the market for a long time however, they have yet to reach acceptance by the society. This can have several reasons, too expensive, to complicated or the market not being mature enough. As mentioned in "Preparatory study on Smart Appliances Task 2 Economic and market analysis" by (Ectors et al., 2015) it was because of the internet of thigs (IoT) hype in 2014 and 2015 that the smart house achieved greater visibility in the public. This shows that even though the smart house concept has been around for a long time, it has yet to reach full acceptance in the public. Based upon this I believe this master thesis serves a purpose in the smart house research, focus on the consumer will be a help when it comes to gaining acceptance with the public.

The essence of a smart home is the use of information and communication technologies (ICT), how this is distributed throughout the house, devices used, HVAC controlled and information / feedback provide to the consumers. A smart house can also be seen as the end-node of the smart energy system that allows the utilities to respond on real-time information regarding energy use with the use of smart meters. (Wilson, Hargreaves, & Hauxwell-Baldwin, 2015).

Chapter 1 served as a general introduction to this thesis and the related topics. When it comes to the smart house concept, energy management and business intelligence there are considerably research on these areas and as mentioned in section 1.1 I believe it that there is too much focus on the technology and not sufficient enough focus on the consumers. Based upon this my opinion is that these research areas need to focus more on the consumers, and this thesis aims to do this.

This thesis will also have focus on consumer control, how the behaviour can change by using different methods and how the smart house concept can be optimized so that consumer satisfaction can be greater. The research will also be limited the demographic group most likely to consider or use a smart house system. This thesis will also analyse how psychological elements in combination with the mentioned technology can be used for improving the consumer's decision-making process. This being a computer science related thesis there is limitations regarding the psychological elements. As mentioned in chapter 1 to change the behaviour requires change in the attitude, developing solutions for attitude change requires a person educated in the field of psychology. However, this thesis will look at how the improved smart house concept can serve as a motivation for behaviour change.

This thesis aims to combine the positive benefits of the smart house concept, business intelligence and energy management and how this can be used for improving the experience for the consumer. The consumer will be in focus without discarding the good from the technology. This will be done by using different methods; described more thoroughly in chapter 3.

2.2 LITERATURE REVIEW

Before starting this master thesis, a systematic literature review was completed. This review was based on (Kitchenham et al., 2007)'s Guidelines for performing Systematic Literature Reviews in Software Engineering. The complete review is enclosed in appendix 1. However, the latter mentioned review formed the basis for this section of the thesis. As with the initial review, the search phase in this thesis was performed in a series of steps, shown below. These steps is also inspired by (Kitchenham et al., 2007). Some of the related work in the next section is related to the literature found in the latter systematic literature review.

1. Run the searches in different search engines. Use the same keywords and layout in the different search engines.
2. Read the titles and abstract. If it seems interesting read the rest of the article quickly, then write a summary, and save for later comparison.
3. If the article is interesting, look through the bibliography for more relevant titles and collect the information.
4. Continue the search until there is 10-15 relevant literature findings.
5. Compare the relevant findings and summarize the interesting findings.

As with the systematic literature enclosed there was different search engines in use, shown in the list below. The reason for using these search engines is based on the information provided in the library course 2nd of September 2015 at Østfold University College.

- ORIA www.oria.no
- IEEE Xplore www.ieeexplore.ieee.org
- Science Direct www.sciencedirect.com/
- ACM Digital Library www.dl.acm.org/

The search words used in this thesis was divided into 3 set of keywords. Each search included publications published between year 2000 – 2016, only peer-review journals were considered. The keywords was put together according to (Search & Write, 2015) they recommend the use of the words (And, Or, Not) when the research question has become clear.

- (Smart house) AND (Energy management OR Energy Awareness) AND (Behaviour Change)
- (Smart house) AND (Business Intelligence) AND (User-centred approach)
- (Smart house) AND (Energy management) AND (Business Intelligence) AND (User-centred approach) AND (Behaviour change)

The results were by default sorted by relevance; and in most cases, this provided a decent outcome. According to step two in the list above, the most interesting findings were read and compared to each other. As with the systematic literature review mentioned the "other users also viewed these articles" www.sciencedirect.com proved valuable.

2.3 Related Literature

The search was conducted according to the process above in section 2.2; this resulted in numerous findings. Many of the results was in some way related to this thesis, this is because the research topics are popular and have been for some years. This led me to choose related work that are directly relevant for this thesis. Since the research topics are so popular, even choosing literature directly relevant for this thesis provided me with many articles.

2.4 Smart house

As mentioned in chapter one, the smart house concept is nothing new and fancy. These days almost everyone is familiar with the term, but that does not mean everyone understand what it implies. If one askes the "man on the street" to explain what a smart house is, the answer will most likely be a house that it environmental friendly, uses some form of renewable energy, sufficient insolation and have lights that are controlled by some form of timer or sensor. Some might also say the technology is what makes the house smart and to a certain point, this is true. All of the latter mentioned aspects is a part of making a house smart, however what makes a home truly smart is the way the residents interact with the technology (Harper, 2003).

One essential element in the smart grid is the smart building or smart house, where the monitoring of real time energy allows more control for the consumer, amongst other beneficial. To provide this there is a need for home energy management systems (HEMS) according to (Siano, Graditi, Atrigna, & Piccolo, 2013). In their article, they design and test a decision support and energy management systems for smart homes. As the authors discuss in their article, over the resent years there have been proposed different forms for HEMS, ranging from different algorithms and energy hubs to different forms of energy consumption games based on game theory. (Siano et al., 2013) describes their decision and energy management system (DEMS) and what input, information and output it contains of, as well of the different scenarios the customer can choose based on their preferences. Their test strategy aims to check if the system operates as normally, as expected by the customer and achieves the expected benefits. To do this (Siano et al., 2013) created four scenarios and test each of them separately. One finding that is for interest for this thesis is the fact that the user comfort is more important than the economic criteria. Nevertheless in their conclusion (Siano et al., 2013) claims that the DEMS allows reduction in energy costs during the economic scenario with about 18%.

When it comes to smart houses and homes the aim is to provide comfort, convenience and safety as well as allowing for more efficiency of energy use. Even though the smart house technology and concept have been promoted for several years, there are some social barriers for adopting the smart homes as discussed by (Balta-Ozkan, Davidson, Bicket, & Whitmarsh, 2013) in their article.

For exploring this, the authors used a combination of public workshops, expert interviews and reviewed existing literature. From the workshops the authors identified that the main concerns of the public were; loss of control and apathy, reliability, viewing smart home technology as divisive, privacy and security loss, cost and trust. The expert seemed to agree on the practical social barriers (reliability, security). One key element identified by one of the experts interviewed by (Balta-Ozkan et al., 2013) was that the smart home marked is a young industry trying to understand what it is that actually is of interest to the consumers. This in my opinion is a barrier for adopting, the consumers know what a smart home is, but if the smart house marked itself does not know what interests the costumer the consumers does not want to adopt something that might not be of interest. Only the consumers that are highly motivated and interested is willing to adopt something so young.

In their paper "A review of smart homes – Past, Present and Future" (Alam, Reaz, & Ali, 2012) states that a smart home is an application of universal computing in which the home environment is monitored by ambient intelligence to provide context-aware services and facilitate remote home control. They describe previous research regarding smart houses, and how technology has progressed. In their paper they describe how the smart house concept can be used for improving the three of the most popular research areas within smart house research; comfort, healthcare and security. The author's states that a house needs three elements to make it smart: internal network, intelligent control to manage the featured systems and products enabled for home automation. These elements however can only be as smart as the residents and their usage of the utilities. In their paper (Alam et al., 2012) talks about how smart houses can offer a better quality of life with the introduction of smart appliances

The need for understanding the users of the smart house and what their key challenges are, is something that (Wilson et al., 2015) also identifies as important. In their article they conduct a systematic literature review and analyse 150 peer-reviewed academic publications and organised them in three groups, and based upon analysis of them challenges were identified. The potential users according to (Wilson et al., 2015) based on their review includes low and middle income households as well as high income, however they also identifies women, children and families rather than unitary households or individual users (e.g. only men). The authors also points to the fact that smart homes are yet to be realised at scale and (Wilson et al., 2015) acknowledges the social barriers mentioned by (Balta-Ozkan et al., 2013) and the results is that the current vision of smart homes have a limited appeal to consumers because the smart home are failing to meet the consumer's needs. (Wilson et al., 2015) concludes that there is a need for developing a better picture of who the consumers are and how they might use a smart home. The major concern for the consumers according (Wilson et al., 2015) are privacy and control.

The general thought behind smart house solutions is that everything is to be controlled from a central device or an application. Such solutions have been researched on for some years and the fact that they have yet to reach population shows that most people might consider those solutions as something for the specially interested. In their article (Hargreaves, Nye, & Burgess, 2010) discusses this phenomena with the use of a qualitative field study in England. Their focus is on households learning to live with visual energy displays and they point out some interesting findings. One being the fact that this form of visualisation of energy in most cases either empowers or disempowers the inhabitants of the house.

Enova (enova.no, n.d.), a public enterprise owned by the ministry of petroleum and energy works for an environmentally friendly consumption and generation of energy in Norway. This is done by providing a founding for everyone that wants to do an effort for the environment by making their house energy smart.

This sort of incentive or reward merely serve as an motivating factor for adoption the smart house concept as stated by (Zipperer et al., 2013). Such incentives do not ensure that the smart house concept will be a success after the incentive has been rewarded. A small incentive tends not motivate people and they fall back into their old habits and behaviour after the incentive has been removed. However, a form of incentive can be serve as a motivational factor for smart house adoption, if used right.

Over the last decades, the technology has exploded and in almost every home one can find smart devices, computers and appliances that can be controlled. However, in my opinion there has been little attention regarding the users, it appears that the focus has been on the technology and perhaps regarded as a funny gadget as section 2.4.1 shows. Today numerous technologies can be implement to get a smart house. There is starter kit available in electro shops and a search on the internet shows different examples of what can be controlled. The possibilities can seem endless, as mentioned in chapter 1.

The sections above just show that the smart house has come to stay, however the smart house marked needs to understand what their users want. Furthermore, how can it be used efficient and provide the optimal energy management? The solutions provided these days appears to be discarded after a period and the residents then go back to their old ways, as the systematic literature in appendix 1 showed**.**

2.4.1 Smart house adoption

With the concept of smart house rapidly growing, it provides a new way of looking at what role the energy plays in the consumer's everyday life. The relationship between the utilities and consumer are evolving and changing and this is where the smart house can create opportunities for the parties involved. The traditional home as we know it has been around for a long time and the use of household appliances and the way they are operated have not changed much over the last years. They way consumer's lives and uses their home have been attuned over the last decades and to take a leap into the smart house era can be a big step for many. (Balta-Ozkan et al., 2013) have identified different social barriers to the adoption of smart homes:

- **Fit to the current and changing lifestyle**
  The technology must fit in with common or acceptable routines. The presence of new technology in the day-to-day life may lead to changes in routines or social norms. If the smart house technology requires any significant changes the consumer might feel that he/she needs to be more involved that desired or feel the control is lost. The user should not have to develop technological skills in order to use and control the system.
- **Reliability**
  Reliability does not only refer to the technology that it will not malfunction. It also refers to the fact that the system as of today is not intelligent enough to understand its users. The ability of smart homes to understand its users are limited. Because of this, the users might not rely on the system to execute the desired choices.
- **Privacy and security**
  For a smart house system to be able to best support their users it is necessary that the system collect data. The manufacturers of the devices and system then face the challenge of ensuring that the collected data is not misused. It is also necessary that the devices themselves cannot easily be compromised.

- **Administration**
  When technology moves into the house, it raises the question who is responsible for installing, upgrading and maintaining the smart house software and hardware? It this something that can be required of the users? Because of this, it will be required that the users have a minimum of understanding of how to manage and troubleshoot the smart house system. This is also something that could be outsourced to a third party.
- **Interoperability**
  The smart house system should be able to easily adjust to new devices and add them to the network. The problem here is all the different manufactures and they all favouring different types of communication protocols. The interoperability barrier is not a new challenge in the smart house environment however, a good solution to this problem is hard to find.
- **Consumer perception of smart home**
  As the smart house is not a technology as such, but more an application that one can use has led to some areas, concerning the smart house has received more research attention than others have. One of these areas is energy and energy consumption researched, and one aim being the transition to a smarter grid. Because there is a technology gap between the consumers and the utilities, the utilities will not likely put much effort into educating the consumers. A possible solution will be that the utilities tries to persuade the consumers into trusting them more and let the utilities take more control.

2.4.2 Challenges on the subject of Smart house

When it comes to the smart house, there are undoubtedly some challenges, major technology developer's fight side by side to develop the next smart device the fastest. The smart element is to be embedded into almost everything and with that making everything smart and connected to the IoT. In addition, by this making our lives easier, smarter and comfortable to mention some. However, how can technology do this? The article from (Alam et al., 2012) mentioned in section 2.3 aims to give a review over the smart house history and identifies future directions of the smart house research, however one element missing is the *user*. This problem is starting to get more attention from some social science researchers as mentioned by (Wilson et al., 2015) and (Bitterman & Shach-Pinsly, 2015). One key issue I want to address when it comes to the smart house concept is the lack of interest regarding the user. (Wilson et al., 2015) also discuss this in their article that a clear user-centric approach of smart houses in currently missing from this research, because the "push" comes from technology developers. For the smart house concept to be adopted by "the common man" and eventually be a success, the user needs to be more involved. Another aspect worth mentioning that also can be a threat to the smart house is the security aspect as mentioned by (Corno, Guercio, De Russis, & Gargiulo, 2015), (Alam et al., 2012) and (Wilson et al., 2015) to mention some. This issue is nothing I will address in this thesis but it is worth mentioning since this is a critical issue for most users.

2.4.3 In Summary

This section has shown that smart houses has been a subject for researchers for many years. The smart house is one of the key elements in the smart grid and therefor the focus on energy saving has been so popular. For achieving this, different form for home energy managements systems has been developed. However as discussed by (Wilson et al., 2015) there is a need for understanding the users and knowing what their key challenges are. When this is achieved the smart house can improve the three main research areas discussed by (Alam et al., 2012).

However it is not enough to identify and understand the users, there are social barriers to overcome as discussed by (Balta-Ozkan et al., 2013), to achieve a higher adoption rate of the smart house the social barriers must be overcome.

For controlling the different devices in a smart house the internet is mainly used to enable the consumer to remotely control the devices and sensors, this again forms the basis for energy management. The problem with the latter however is that consumers know the concept of smart house but it might seem overwhelming. The next sections will look at energy management and business intelligence techniques, something I believe will make the smart house more graspable.

2.5 Energy Management

Energy management means to control and reduce the energy consumption. According to(BizEE software Ltd, n.d.) this is important because it enables the consumer to;

- Reduce cost
- Reduce carbon emission

(BizEE software Ltd, n.d.)list how energy consumption can be monitored and managed;

- Collect data about the energy consumption
- Find and quantifying opportunities to save energy
- Target the energy saving opportunities
- Track the energy saving process

As the list above shows, one must take in account a number of elements to be able to obtain an efficient energy management process.

Energy saving and reduction has been a topic of interest within computer science for a long time, it has been developed several different products aimed at this field and the field is expanding. Common for many of these products is that they are aimed at the residential home market; one reason is that residential homes are a major contributor to greenhouse gases and global warming and even though this today is common knowledge, the energy use in households keeps rising. (Abrahamse, Steg, Vlek, & Rothengatter, 2005). In their article (Abrahamse et al., 2005) discusses what factors that contributes to this increase, something called TEDIC factors (**T**echnological development, **E**conomic growth, **D**emographic factors, **I**nstitution factors and **C**ultural developments), they points to the fact that the TEDIC factors again shape individual factors as motivation, abilities and opportunities. (Abrahamse et al., 2005) also points to the fact that if ones aim is to change the consumption pattern the above mentioned factors must be considered. In their article they discuss different types of antecedent intervention studies (goal-setting, information, workshops, tailored information and mass media campaigns) as well as the consequence intervention strategies (different forms of feedback and rewards). The conclusion is that interventions to promote energy saving within residential homes have got varying degree of success. In general information types of intervention has a limited effect, and that is something I have to take in consideration. Rewards on the other hand has a positive effect but that seems to disappear when the reward is removed, continuous feedback is the intervention that seems to be most successful for reducing energy. The authors also mention that many studies have concluded that continuous feedback has proven most effective but in reality other intervention strategies has been used as well. (Abrahamse et al., 2005). It is also pointed out that most people that participate in these kind of studies are highly motivated, having a higher education etc.

This article supports my idea when it comes to energy reduction and behaviour change, by changing behaviour energy usage can be lowered or altered.

This idea is also supported by (Steg, 2008), in her article she discusses different factors which influences energy saving, what motivates it and strategies to promote household saving. (Steg, 2008) points to the fact that most people are aware of the problems related to household energy use, however what people don't know is the fact that their usage are related to their behaviour. The author also mentions that people think that energy usage is related to appliance size and that the amount of energy used in heating water etc. are underestimated. (Steg, 2008) also discuss the elements of comfort and effort vs. saving, people are less willing to save energy when it impacts their comfort level. The author mentions another important element when it comes to other studies on the area; most of them only consider direct energy usage not indirect energy. The direct usage is the easy one to reduce but it is the indirect usage is the one that can be changed by changing behaviour. (Steg, 2008) also discus personal factors, and that those should be acknowledged alongside contextual factors. The important element in this article is that people in general know little about how much energy their behaviour use. (Steg, 2008) talks about the importance of tools that can provide people of information regarding energy reduction and feedback about how their behaviour impacts usage and how changing this can led to reduction.

In the article from (Wilson et al., 2015), discussed in section 2.4.1 they also recognise the fact that goal-oriented view of smart homes emphasise the their potential to help achieving reduction goals (amongst others) and their associated benefits for the households, utilities and policymakers. The aim of the households is trying to save money, and to achieve this the utilities needs to improve their energy system management. (Wilson et al., 2015) mentions a study conducted in the UK regarding attitudes and values towards energy systems found it to receive general support but with warnings around the areas of data sharing and alleged loss of control. It is not difficult to understand why users are reluctant to share their private data and the feeling of loss of control. When sharing data and giving the utilities possibility to take control can be frightening, the user knows what data the utilities say they will collect but the users have little or no warranty that the data will not leak.

For a homeowner to achieve a method of executing energy management, a method is needed and a plan for monitoring and collecting data, this is where the business intelligence and analytics comes in to play, see section 2.6. This shows that energy management have a potential for reducing energy consumption, improve saving and this has a positive effect for the private consumer as well as the for a large hospital e.g.

2.5.1 Challenges on the subject of Energy Management

Energy management can represent an opportunity for the consumers to reduce their usage. However, for the consumer there are some challenges involved. A part of achieving energy management there is a need for demand response, the challenge with DR is the fact that most consumers have neither the time nor knowledge to perform the necessary actions involved in load shedding. Energy management requires a minimum of knowledge regarding energy usage, household appliances, energy prices and so on, this is something the consumers need to acquire more knowledge about in order to obtain the desired level of energy management. The utilities on the other hand cannot require the consumers to educate themselves on those areas. For the consumer to obtain a better sense of energy management they will need to make several changes and adjustments in their lives.

Nevertheless, even though most of the information on can find when it comes to energy management relates to larger buildings and non-residential building, most of the principles can be applied to residential homes. It is also essential that residential homes will be more attentive when it comes to energy management because most of the homeowners have a "driving in the dark approach" towards to energy usage. (BizEE software Ltd, n.d.). Energy management is important because the world's energy consumption is high; this is not just in the residential sector, but also in the production industry. Today with the renewable energy sources available as well as the technology rapidly developing the possibilities for energy saving can seem endless. However, energy management is not a one-time job or process, it is a continuous process and for homeowners this might seem like an unachievable task as well as time consuming. With that in mind, it becomes clear that energy management does not depend on the technology; rather it depends on how the users and homeowners are able to respond to the ever-changing energy situation. With the ever-changing situation regarding innovation, increased efficiency regarding household appliances and the technology. For the homeowners to obtain optimal energy management at all-time requires that he/she is always up to date on what it going on regarding energy related subjects. Such a task is almost impossible for the average homeowner.

2.5.2 In Summary

Energy management involves different actions and steps to plan energy consumption, meet requirements from the government and planning and operation of energy production. The term has been known in non-residential sectors for a time and now the residential sector is more aware of the concept. There are several challenges when it comes to energy management, these are somewhat related to the challenges of adopting the smart house technology.

In this thesis I choose to incorporate energy management because I do believe that the private consumers need to change their approach regarding their energy consume. As mentioned in **chapter** 1 most homeowners take a "driving in the dark" approach when it comes to energy, and only tries to take action when the utility bill is too high. This is where I believe energy management can make a difference.

2.6 Business Intelligence And Analytics

The term "Business intelligence" (BI) dates back to at least the 1860's, however it was not until the 1989 that Howard Dresner was credited for proposing BI as an umbrella term. (Rouse, n.d.-a)

Gartner defines business intelligence as:

> *"*Business intelligence (BI) is an umbrella term that includes the applications, infrastructure and tools, and best practices that enable access to and analysis of information to improve and optimize decisions and performance." *(Gartner Research, n.d.)*

The goal of BI is interpret the large volume of raw data and transform it into meaningful information that can be used to evaluate previous (historical) performance as well as current and predict the future. The main goal is to identify new opportunities and strategies. Business intelligence combines architectures, tools, databases, analytical tool and methodologies, and as the definition from Gartner above shows, BI can mean different things to different people. According to (Turban, Sharda, Delen, & King, 2011), a business intelligence system has four major components; data warehouse, business analytics, business performance managements and a user interface.

They key is to identify where the difference is and what components one should use, and the key is to provide the right information at the right time. Business Intelligence can show the general trends, information, reports and business Analytics "digs deeper" in the information provided. (Davenport, 2010). The problem with business analytics on the other hand is because it uses quantitative and statistical analysis and according to (Davenport, 2010) this approach are insufficiently linked to decision-making. Data is gathered but not used, and decisions are made on intuition rather than data and analysis. However, for the end user to work with the data and information it is required that the information is processed in a form of data warehouse; this is done with different tools and techniques. According to (Turban et al., 2011) the latter can be divided into two main categories; reports and queries, data, text, web mining and other mathematical and statistical tools. To obtain the idea that the consumer should be more involved, this thesis will focus on the analytical aspect and reporting. By focusing on analytics, the user can potentially get different forms of reports both static and dynamic as well as discovery new information that can be at interested. (Turban et al., 2011). Analytics performed on data warehouses are in use today in different smart house solutions, that is nothing new, however as mentioned, this thesis will focus on a higher abstraction level and not the technical. The data warehouse analytics and real-time streaming of information is mainly what the smart house concept focuses on as of today. The successes of business intelligence depends highly on how it is used and by whom, in their book (Turban et al., 2011) mentions the importance of knowing why one uses BI. In addition, the authors states that BI needs be aligned with the company's business strategy; it must serve as a way to provide change for the business (in this case, the house and the families living there). This can be done by improving the processes and transforming the decision making progress to be more data driven according to (Turban et al., 2011). Even though business intelligence is mainly for a complex business environment that is rapidly changing and that making decision making more difficult, the same could be said about the smart house, with the increase of collected data with the introduction of smart meters. There is a need for not only having information systems to analyse the data but also making sure the consumer understands the provided information.

In his article (Ranjan, 2009) explores the concepts of business intelligence, the components, benefits and various BI techniques, amongst others. The author discusses the different components which makes up business intelligence, and one component important for this thesis is the "advances analytics" which refers to data mining, forecasting or predicted analytics, this is done by the use of statistical analysis techniques. Another important element mentioned by (Ranjan, 2009) is the data sources, one can use operational databases, historical data, external data or already existing data even spreadsheets or unstructured information. (Ranjan, 2009) points to one important part and that is the analysis of the right information, for this thesis this is important in providing the right information to the consumers so that they can take the right decisions. To do this the right form of input is needed, if that is done correctly, BI can eliminate a lot of guesswork and enable the consumers to quickly respond to changes or information based on their preferences. (Ranjan, 2009) also points to the fact that BI perfections decision making process with its advanced analytics. The author also proposes questions one might take in account before implementing business intelligence, the list below shows what I consider important for this thesis:

- Determine the goals.
- Determine who will benefit from the initiative.
- Desired results

The list above inspired by (Ranjan, 2009) shows that the consumers' needs to take an active approach if BI in combination with smart house and energy management should be beneficial.

In their article (Zhou & Yang, 2016) discusses how one can understand the energy consumption behaviour through the contribution of energy big data analytics. The review of behaviour part of the article can be found in section 2.7. The large amount of data about energy consumption are generated, collected and stored and can serve as a valuable resource to support smart energy management, the near real-time collection can be used to support behavioural change. (Zhou & Yang, 2016) discusses big data and the impact a network with smart meters that collect data can have. In addition, as the authors point out, the data collected is meaningless unless it is explored and mined with the aim to support the consumer. When it comes to big data and analytics and consumers the authors identify that the value lies in energy saving, operational efficiency and improved visibility in how they use energy. It is also concluded that energy and big data analytics have opportunities for understanding household energy consumption behaviour (Zhou & Yang, 2016).

2.6.1 Challenges on the subject of Business Intelligence

From a traditional perspective, BI is used in larger companies and because of this; most of the identified challenges are related to the latter. However, there are some challenges related to smart houses, energy and BI. For all users of BI the difficulty in acting on what one learn are a common problem, business intelligence provides an overview and insight but it does not tell the users what to do. It also requires time and effort for BI to be profitable and for it to encourage action filled steps. The key however is to provide the right information at the right time and with the right tool. More important is to know what the right information for that specific user is. With the ever-expanding use of technology everywhere it will cause information overload, this will leave the persons taking the decisions overwhelmed with inadequate or incorrect data and potential led to wrong decisions being made. This can be critical for companies but it can also cause problems for residential homeowners. If large companies have problems with using BI in an efficient way, it is also fair to believe that BI in combination with smart houses can be complex and difficult to. The way I see it is that BI techniques can be a part of the decision-making process for the consumer, by providing the right information at the right time. This however requires some effort from the consumer when it comes to identifying what the right information and right time is. As stated by (Davenport, 2010) one of the issues with business intelligence is that it is primarily about generating standard reports or answering queries as well as lacking precision to what activities was included

2.6.2 In Summary

Today, it is difficult to find a successful enterprise that has not leveraged BI technology for their business (Chaudhuri, Dayal, & Narasayya, 2011); they have cracked the code on how to use it and what information they need. However, there are some work required to get there and that amount of work can be intimidating for the residential owners. Nevertheless, BI has proved valuable for companies that has managed to successfully implement and use BI so it can potentially be a part of a successfully solution in a smart house system. However, business analytics with its deeper insight in the data provides more information that the consumer can base their decisions regarding energy management on. They key is to know what components to include from business intelligence. That is something I will try to find out in the interviews and participatory design workshop, described in section 3.3.1 and 3.3.2.

2.7 BEHAVIOUR CHANGE

Behaviour change refers to the transformation of human behaviour. There are number of variables that can trigger a motivation for change. It can be a treat, fear, intentions or benefits, to mention some. All of these have in common that they trigger the human brain to think different and encourages change. There are many known behavior change theories that tries to explain why the behaviour changes in different scenarios; however, this thesis the focus will be on behaviour change and energy.

Theories and models of human behaviour come from many different science disciplines; the largest number of studies comes primarily from psychology and focus mainly of the individual as the locus of behaviour. Meaning it is the individual that holds the key for change, and can control events affecting them. Then again, there are other theories that focus on the behaviour itself or the relationship between behaviour, individual and the social/physical environment where they occur.

The need for understanding and changing residential home energy consumption behaviour is identified as important by (Zhou & Yang, 2016). In their article they discuss this topic and as (Abrahamse et al., 2005; Steg, 2008) in 2.5 they discusses the importance of addressing this aspect. (Zhou & Yang, 2016) talks about the amount of data collected with the use of information systems and how it can be used as a valuable resource to support smart energy management with the usage of big data analytics to reveal hidden behaviour patterns. The authors discuss the well-known demand response programs, an effective way to promote energy conservation through price or incentive based strategies, for this to be successful the amount of data collected are important, this however requires that the consumers allow data collection on a larger scale. (Zhou & Yang, 2016) also discuss the use of behaviour-oriented paradigms such as feedback, goal setting and information, they point to the fact that behaviour factors have a significant effect on residential energy usage. The fact that people have little or non-knowledge about their indirect energy use and how that impacts other aspects is also something that (Zhou & Yang, 2016) mentions.

Others that have acknowledge that households are an important group to address when it comes to energy conservation is (Benders, Kok, Moll, Wiersma, & Noorman, 2006) and in their article they develop a web tool for addressing this issue. They focused on that the participants got more personal feedback and reduction options, and indirect energy usage was taken into account. For evaluate if the tool met the goal of reduction it was performed a field experiment with 347 households in the Netherlands. The web tool consisted of tree parts (questionnaire measuring energy requirements, information on how to reduce energy and feedback). It was also defined criteria's related to energy behaviour that the authors addressed in the experiment. However only 190 completed the experiment and because of that the total energy reduction was not significant and the indirect energy saving was not significant either, for me this is important because I then need to find a way to make sure that the consumers do not fall back in to old habits regarding indirect energy use. This is also stated in the article that more research is needed on the fall back behaviour. It is also mentioned that from the literatures standing point one can conclude that at least part of the energy saving behaviour will not last because people fall back into old habits. (Benders et al., 2006) The authors proposes some recommendations for keeping energy saving and the proposed web tool interesting.

The aspect of habits and energy has been a subject of interest for many researchers and one article of interest for this thesis is the one from (Pierce, Schiano, & Paulos, 2010). In their article, they investigate the relationship between "normal" domestic interaction with technology, energy consumption and the design of everyday products and systems.

By doing this the authors aimed at uncover what “normal” interactions are and how that can be designed around technology to be more sustainable. The reason for looking at this is important for this thesis because the majority of interactions around energy seems to be performed without conscious consideration of energy, as mentioned by (Pierce et al., 2010). They investigated the latter by performing interviews, card-sorting exercise and logging activity. In the article, it is also pointed out that it is difficult to understand people’s habits and everyday interactions as these might change over time and with context. Another important finding in the article is that the participants did not have an understanding over how much energy the different appliances used, expect from the HVAC appliances. Because the bills spiked with seasonal increase in use. When it comes to the habits, (Pierce et al., 2010) observed that the usage of domestic appliances can be characterized as unconscious or habitual rather than rational decision-making. This is something that was recognised by (Abrahamse & Steg, 2009) .

Even though those two articles have different focus (habits vs. indirect use), it boils down to the fact that people are not aware and usage pattern is controlled by habits. In this article from (Pierce et al., 2010) they conclude that people are often unaware of energy conserving options, they often rely on habits and split-second decisions. The authors also state that the everyday domestic environments are not designed to promote and sustain energy conserving interactions. To overcome this the authors proposed that the environments must be redesigned with the use of human-computer interaction and interaction design.

2.7.1 Challenges on the subject of Behaviour Change

With all the new technology it can seem like technology is the option needed for achieving behaviour change. Smart phones for example are able to collect accurate data regarding how many steps one walk every day and so on and it might look like this will be a motivator for walking even more, since we more or less always have our phones with us. Wearable devices is a technology with the aim of making users achieving behaviour change and the use of wearables have increased in the last years however according to (Ledger & McCaffrey, 2014) the users will often stop using the devices within six months after purchasing it. The same trends can be seen when it comes to behaviour change and energy, users will go back to their old habits or stop using devices giving feedback or shows visualisation after a period. One reason might be that the feedback device is too generic and not individual enough, since the behaviour change triggers are individual.

2.7.2 In Summary

Behaviour change and energy is a complex topic that involves a range of different approaches to address it. Behaviour change is a subject psychologist has worked on for decades and there has been developed many models for trying to understand what triggers behaviour change. As mentioned in section 2.5.1 when it comes to energy, there is a common understanding amongst researchers and utilities that some sort of feedback device is the way to achieve change. As mentioned in section 2.4 the participants in different research project that involves feedback devices might be extra motivated at not representative for the community.

When it comes to energy saving and behaviour change, research has shown that in general terms information alone is not an effective strategy (Abrahamse et al., 2005). A common perception when it comes to energy saving and behaviour change is that some sort of feedback device is the golden ticket, especially a smart meter. In their paper (Abrahamse et al., 2005) discuss different studies where feedback seemed to have an positive effect, however as mentioned in the paper, households who participate in these studies tend to be motivated, have higher education level and making generalization difficult.

Regarding behaviour change, (Abrahamse et al., 2005) discusses papers who has combined feedback with a goal setting, these found results in shifting in consumption time but no difference in overall consumption. One thing worth noticing is that in almost all of the studies reviewed the behaviour change effect was not measured over a longer period of time. According to the authors the studies they have discussed revealed that underlying factors of energy use and energy related behaviour hardly have been examined.

2.8 Design of Everyday Things

Donald Norman, a man best known for his book "The Design of everyday things" is highly regarded in the fields of design, usability engineering and cognitive science. The latter is the reason for why his book is important to this thesis. In his book (Norman, 2013) discuss how the design serves as a communication channel between the object and the user, he also discuss how to optimize this communication by acknowledging the human mind and how it works hence the use of behavioral psychology. In chapter one (Norman, 2013) talks about the fact that all artificial things are designed, from garden paths to complex control rooms. Donald (Norman, 2013) states that the interplay between technology and people is important to acknowledge to ensure that the product actually fulfill the human needs while being understandable and usable. Meaning the products must not only fulfill the requirements from engineering, manufacturing etc. but also pay attention to the entire experience being the whole experience. In his book, (Norman, 2013)states that people are frustrated with everyday things, because they are getting to complex, too much automation, and a never-ending fight against confusion, continued errors, frustration and a continuous cycle of updating and maintaining the devices. One important aspect discussed in the book is conceptual models to be more specific; mental models, conceptual models in people's minds. These represents the understanding of how things work and vary from person to person. Such models are often derived from the device itself and some are passed on from person to person. Donald (Norman, 2013) talks about how persons create mental models of the things we interact with, these are conceptual models based on experience, training and instruction, the problem is that the designers conceptual model is not similar to the users conceptual model that is why understanding the user is so important. The author also talks about the paradox of technology; it is supposed to simplify life by providing more functions but it also complicates life by making the device harder to learn and use (Norman, 2013). When people encounter a device, they according to (Norman, 2013) face two gulfs; Execution and Evaluation, see figure 1.

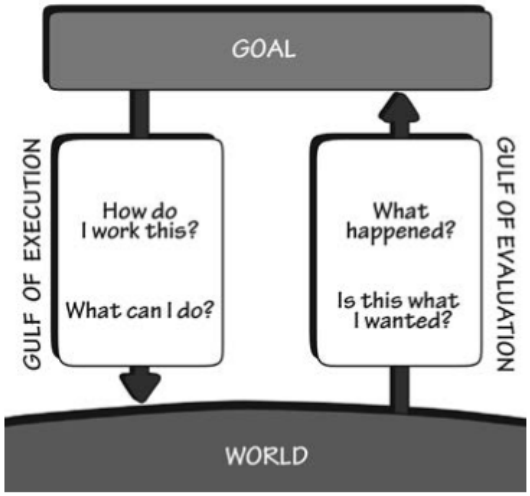

Figure 1 Gulf of Execution and Evaluation (Norman, 2013)

This gulf needs a bridge and it is here the design comes into play. According to (Norman, 2013) to bridge the gulf of execution one needs mappings and conceptual models (to mention some) and the bridge over the gulf of evaluation need the use of feedback and conceptual model. To do this, (Norman, 2013) proposes a seven stage of action cycle se figure 2, goal is the seventh stage.

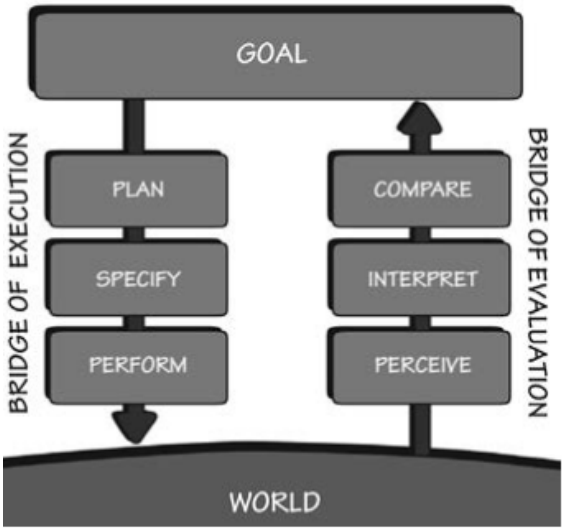

Figure 2 Seven stages of action (Norman, 2013)

This seven stages of action cycle provides a useful framework for understanding the user and their actions. Most of the activities humans do every day are opportunistic and does not engage in planning and analysis the activities are done as the opportunity arise according to (Norman, 2013), this is one of the aspect this thesis aims to address when it comes to energy management and try to make use of the mental models and the seven stages of action cycle. Another element that according to (Norman, 2013) is underrated is emotions; while cognitions tries to make sense of the world, the emotional system determines whether something is good/bad, desirable/not etc.

2.9 In Summary

In this section, the above-mentioned topics will be linked to the research questions in chapter **1.2**. If the smart house concept shall encourage the consumers into obtaining energy management in a more effective level, the need for more knowledge is necessary. When it comes to smart houses as of today, the ones that implements the technology and related methods are above average interested in the concept.

As this literature review has shown, there is much research regarding smart houses but it has yet to gain popularity amongst the common person. For the sake of the environment as well as personal interest, there is a need for making the smart house concept more widely available. By looking more closely into the psychological aspects that surround the concept and human behaviour in combination with energy management and BI approaches smart houses may gain an increase in popularity. As mentioned in (Abrahamse et al., 2005) there is a need for more multidisciplinary perspective when it comes to household saving and using. Increased knowledge amongst the consumers as well as knowledge regarding what triggers the consumers can prove valuable. To achieve better energy management amongst the consumer the increase in knowledge is needed, and increase in knowledge can also led to behaviour change which also can improve energy saving. By implementing BI techniques there can also be an improvement for the consumers.

The literature discussed in this chapter of the thesis is from several different research fields. Behavioural change for example is a field I am not familiar with, and because of my lack of knowledge on that area I cannot go in depth into what exactly it is that triggers different form of behavioural. On this topic it can prove challenging to obtain sufficient knowledge. Because of that, I choose literature that was closely linked to energy related topics and articles that was used in energy related articles. The articles from (Wilson et al., 2015) and (Bitterman & Shach-Pinsly, 2015) related to energy usage and behavioural change also mentions the element of multi disciplinarian research, and that energy related topics need more involvement from social science. This shows that more experienced researchers acknowledge the fact that psychology and habits play a fundamental role in energy related behaviour. In addition, it also shows that the literature I have choose for this thesis might contain flaws because the research needs more input from researchers that have a greater experience in the psychology field.

The energy related literature is an extension of the systematic literature review**.** The literature in the latter review provided a foundation for the research questions in section **2.1**, and therefore it was natural to continue to build upon that literature. Some of the literature in this thesis is also from some of the same authors as the systematic literature review, however the literature used here is more related to the research questions.

The business intelligence related literature also builds upon the literature. In addition, some of the literature builds upon the literature used in the course “IT in business” which I attended the fall of 2012. The literature used in that course served as a basis for searching after more narrow literature, suitable for this thesis.

The “design of everyday thing” book was chosen because of the way the author explains the concept and psychology behind everyday elements. The seven stages of action cycle are useful to consider because in my opinion after doing the two literature reviews, systems for energy usage and saving seems to be designed by people, but without the deeper understanding of people and why they do the things they do. The designs and systems are destined to be faulty. Emotions are also an element worth mentioning, because positive and negative emotions have a great impact on how humans react and think.

In general, the aim was that all the articles were peer-reviewed and the books used all came from well-known academically publishers and therefore served as a primary source. The web sites used were more difficult to determine how objective and academically they were. It sometimes proved difficult to determine where the authors of the website obtain their information from, and because of that websites were only used as a secondary source.

3 METHOD

In this chapter I will describe the methods used, how these relates to my research question, why I choose those methods and what I am going to do, how to collect the data. The work in this thesis is based upon analysis of existing literature, existing smart house solutions, interviews, survey and participatory design.

3.1 CHOICE OF METHOD

I started out by conducting a literature review, the first one can be found in appendix 1 and the second one is described in section 2.2. Both reviews explored the fields of smart house, energy management and business intelligence. By examining the existing materials on the latter mentioned research topics, I ended up with the research question in section 1.2. However, the literature review process in section 2.2 also addresses the field of behaviour change.

The initial literature review provided a valuable insight, overview and understanding of the topics. Whereas the review in this thesis helped building a stronger foundation and provided a deeper understanding. When reading the paper by (Abrahamse et al., 2005) they pointed to the fact that many studies reveals that the underlying factors that influence the behaviour related to energy have received little research. This is something I have to consider when developing a proposed solution to my research question. When examining how to identify underlying behaviour change factors I was introduced to Fogg Behaviour Model (FBM) (Fogg, 2009), this method shows which elements that must unite at the same time for the desired behaviour to occur. This model gave me an overview over the specific elements and subcomponents that is a part of behaviour change when it comes to technology. By investigating the FBM further I was introduced to the concept of persuasive technology, which is technology designed to change attitude or behaviour of the users through persuasion and social influence (Wikipedia, n.d.). Further investigation led me to the concept of human computer interaction (HCI) where I got an overview over techniques that already exist and can be incorporated into a design process. For instance, participatory design is an interaction design method that can be used when one wants to obtain a better understanding of how people think about a given problem, discipline or technology (Austin Center for Design (AC4D), n.d.), this is done by incorporating the users in the design proses.

By examining the current material on smart house and energy management, I got an insight and a deeper understanding of what the research has been focused around. This gave me the opportunity to identify what I need to consider when developing my proposed solution to the research question and what I can disregard. As mentioned by (Solaimani, Keijzer-Broers, & Bouwman, 2015) when it comes to smart house research and publications, the technology aspect is by far the most covered. Even though there are exceptions, there are literature that focuses on psychological aspects these are often dominated by the technological domain. This has an impact on the methods used in the different papers, the paper " A review of Smart homes – Past, present and Future" by (Alam et al., 2012) discusses the different topics of smart homes which are popular in the research field and the associated methods. This made me realize that in order for me to propose an answer to my research question I needed to look at methods related to users not only technologies. This led me to the paper "Designing for user confidence in intelligent environments" by (Corno et al., 2015). In this paper, they propose guidelines for improving quality and engagement of the user experience. These guidelines were based upon (Norman, 2013)'s seven stages of action model.

This model explains the user's cognitive process as he interacts with technology; it suggests a goal-oriented design, which the research question is based on. The seven stages of action model gave me an understanding over the stages that can be involved in an action performed by humans as mentioned in section 2.8.

Based upon the conducted literature review and with regards to my research question I chose to use qualitative methods as a part of my overall research method. The reason for this is that I need to be able to explore the research question in a more in-depth perspective as well as the method being suitable when researching on human behaviour. By using qualitative methods, I will be able to explore the research question with the desired focus on the consumer. In my research I want to investigate how and business intelligence can be combined with energy management in a smart house context and how this can be used for achieving a more effective and usable energy management experience. To be able to discuss the latter I also need to go more in-depth in what triggers the consumer, what are the actions involved and how can it be used subconsciously. As well as how can behaviour change led to a more efficient energy management and how to maintain it. However, in my research I also need to incorporate quantitative method (a survey); this is because I need a broader foundation of data to generalize the results.

3.2 Quantitative And Qualitative Methods

The world can be investigated with the aid of two different research approaches; the qualitative and quantitative. The quantitative methods are based upon numbers and variables that is measurable (quantifiable), these methods investigate numerous units and span over a large area. When spanning over a large are the probability of being able to generalize the results. It is also a way of trying to achieve a precise description of the phenomena across different contexts. The strength when it comes to quantitative methods is that one can investigate a large number of units, its flexible which enables the possibility to change the investigation approach along the way (Jacobsen, 2005). Such methods are great for using when one is interested in knowing how many and wants to falsify hypotheses. One of the biggest drawbacks when it comes to quantitative methods is that they are individualistic, the methods looks at their society members as an isolated unit, and thereby forgets that humans mostly acts as a part of larger group rather that an independents individual. (Jacobsen, 2005).

A reason for the latter can be the fact that the interview methods selects individuals to interview and conducts the interviews isolated from the rest of the "group". The results of the collected data can therefor obtain a static character. Many interview objects can also choose to give a strategic answer and this can make it difficult to see the underlying social processes (Sander, 2014b).

The qualitative methods go more in-depth when it comes to a problem and tries to reveal as many underlying factors, details as possible. These methods aim to provide an understanding to the relationship between what is being exanimated and the contexts where it is situated. (Jacobsen, 2005). In other words, when one wants to understand a phenomenon not measure it. The data collected with qualitative methods can be used for establishing hypothesis that later on can be made quantifiable by using quantitative methods. Qualitative methods provide data such as what, where and how opposite of quantitative methods. (Sander, 2014a). Qualitative methods as the name implies focuses on quality, one gets to research more in-depth and one has the possibility to go even deeper if preferred. However, there are drawbacks there are no definitive answers and it is hard to evaluate whether the answer provided is valid to others outside the group involved in the research. One problem with the informal interview method that is a part of qualitative methods is that the classification of information collected can require much time.

And because many projects have limited timeframe there are often a small selection of participants involved and this means that the results never can be generalised, according to (Sander, 2014a). The strengths of qualitative methods are that when used it can give an overview over the complete situation and provides a possibility to give a better understanding when it comes to different processes and contexts. The research question can be seen from different angels, as opposite from quantitative methods.

As one can see of the two latter sections, qualitative and quantitative methods is not competitors as such. Rather they complement one another, one method cannot function as a substitute for the other.

There are many factors and variables that needs to be considered when it comes to selecting a method, and in many cases, a combination of qualitative and quantitative methods can be a good solution. What sort of data that is going to be collected plays a part in selecting method and how these data correspond with the research question. In this thesis, the aim is to try to understand a phenomenon and therefor qualitative methods are a preferred choice. When using just one method there are weaknesses to consider, as mentioned above.

With a background in the conducted literature review and with regard to the research question on this thesis, I chose to use qualitative and quantitative methods as a part of my method. The reason for this choice was the ability to use semi-structured interviews to explore the user's perspective and perceptions. Another motivation for using a qualitative approach is that I will be able to investigate other interesting elements regarding the research question. By using quantitative methods such as surveys I want to investigate if the results from the Participatory design workshop is the general opinion amongst potential smart house users.

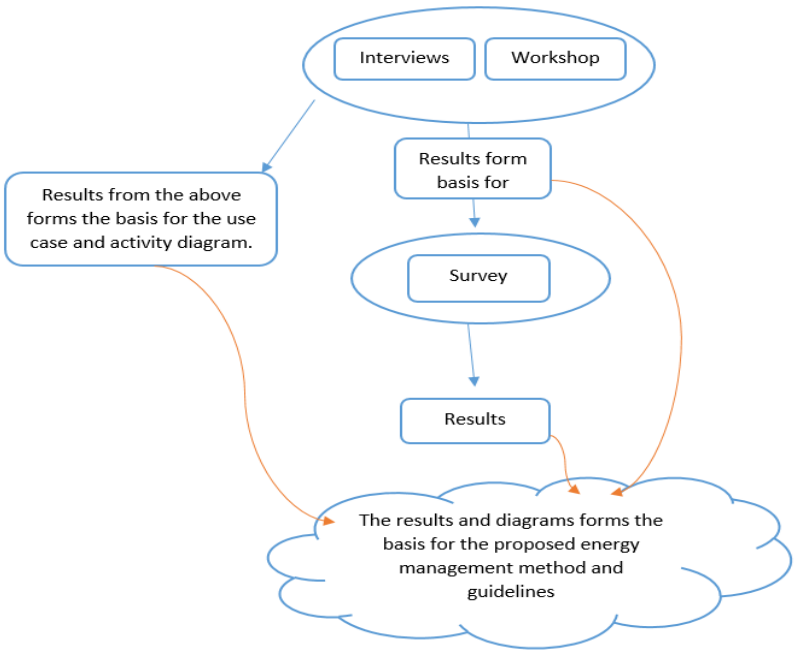

Figure 3 Research method

The research method is shown in figure 3 above; first, I will conduct interviews and a participatory design workshop. The aim for the interviews is mentioned in the section above. The for the workshops is to get an understanding of how the participants think and feel about the problem as well as generating design ideas.

The results from the interviews and workshop will form the basis for the survey; here the aim is to investigate whether the results gathered is the general understanding of the society. The results from this first part will be used to develop an activity diagram that will be used to explore the potential workflow and actions preformed.

By using research with focus on the users, the envisioned users will be able to take an active part in the research.

3.3 Data Collection

When the systematic literature review was conducted the different methods for data collection was noticed. The methods most commonly used were surveys and interviews as shown in the article from (Kastner & Stern, 2015) however the perspective varied ranging from hypothetical to retrospective. Based upon this interviews and surveys will be used in this thesis as well.

As qualitative methods can use a variety of data collection methods ranging from participatory / non-participatory observation, different forms of interviews to mention some. By using the qualitative approach, I want to uncover if incorporating business intelligence techniques into the smart house concept will led to a different level of energy management and if that again can be a trigger for behaviour change. This will be explored with the use of interviews, which will be designed to incorporate a selected number of topics related to the research question. The use of qualitative methods will also make it possible for me to collect data that cannot be easily be observed. The results from the interviews and participatory design workshop will form the basis for the later mentioned survey.

3.3.1 Interviews and Survey

As a part of the qualitative data collection, I will conduct different interviews. The interviews will be open-ended and semi-structured; the interviews will follow an interview guide to ensure that all the topics are covered. This form of interview will also let me follow up on any new topics that may be revealed during the interviews. The interviews will be captured with the use of notes and audio recording. Below is the interview guide, this was first tested on two people before the actual interviews were conducted, to ensure that the questions were easy to understand and left little room for misinterpretation.

- **How will you describe your approach towards energy and energy usage as of today?**
  This is meant as an introduction to “warm up” the respondent as well as get them to think about how their relationship towards energy.
- **Where do you think most of your energy is used today?**
  This question is meant to get the respondent to think more closely on how he/she uses energy, how and where.
- **What is your opinion about smart houses?**
  This question is meant to investigate what the respondent thinks about smart houses.
- **If energy management could provide a significant reduction in cost and energy usage for you and your family, what would it take you to use this?**
  Meant as a question for exploring whether or not the participant considers energy management as something worth considering.
- **If there was a solution that could make energy management easier, (a tool for decision support) is this something that you would consider?**
  Describe the proposed idea to the participant and act as a starting point to whether or not the solution is something a typical user would consider.

- **In your opinion, what incentives is needed for changing your behaviour in regards to energy usage?**
  Asked to investigate what the respondent themselves believes that motivates for behaviour change when it comes to energy.
- **How do you think a visual display can be a help for understanding energy management and changing behaviour?**
  Asked to explore if the respondent has a different opinion in how a display can be used when it comes to the latter.
- **What sort of information do you want to see in a smart house information system?**
  Asked to get more knowledge about what the respondents consider as important information.

3.3.2 Participatory Design

Participatory design is a design approach where the aim is to involve the stakeholders in the design process to ensure that the results meets their requirements. The participants are invited to work together with the designers, researchers with the aim to explore their problems, define the problem and propose solutions. (Kusunoki, 2013). Since this thesis addresses the concept of behaviour and a user centred approach it is only logic to use a method that involves the users. Participatory design sees the "world" from the user's perspective and by the use of this method, the researchers get insight into experiences, knowledge and information that might not be easy to put into words. (Austin Center for Design (AC4D), n.d.) It is not a specific design style; it focuses on the design process and the involved participants. However, this process is time consuming, requires resources, it will only serve as a supplement to the research and the other methods involved, it can be difficult to find participants. When it comes to participatory research, ethical aspects are important to acknowledge, see section 3.4.

3.3.3 Survey

When the participatory design session is finished and results analysed the results will form the basis for an online survey. This survey will be distributed to as many as possible and the purpose is to see if the results from the participatory design session correlated with the general opinion of the public. The survey will also contain questions regarding usage patterns related to energy, size and type of house, how many family members there are, estimate of usage etc. I will use this data for developing a "typical user or family" use cases and activity diagram.

- Generally living situation
- General energy usage discussion
- General usage of technology as of today
- General thoughts regarding smart house
- Energy management
- Motivation regarding behaviour change etc.
- Displays and visual feedback.

3.3.4 Recruitment of participants

The participants will be recruited from school and during the social media "Facebook".

3.4 LIMITATIONS AND POTENTIAL PROBLEMS

The fact that the user group can potentially be every homeowner can be both an advantage and disadvantage. It can be easy to recruit participants that are motivated and eager to be a part of the smart house era, but it can also be difficult in the sense that potential participants see this as a fad and that smart houses will always be for the one extremely motivated. If this is the case, the research will suffer from the same problems as other research projects; only the motivated and curious participants that want to contribute.

This is a problem mentioned by (Abrahamse et al., 2005; Verbong, Beemsterboer, & Sengers, 2013) to reference some. The problem with using only highly motivated participants it that the outcome of the experiments is less applicable to the society as a whole.

Regarding the qualitative methods, the outcome of the interviews depends on my skill as an interviewer. As well how I manage to formulate the questions and follow up subjects that might come up during the interviews. It can also be that I will not manage to follow the same procedure during every interview and this can affect the reliability. When selecting what materials that is relevant a potential problem is that selected materials can reflect personal interests. The process of analysing data can also prove difficult and potential important information might go unnoticed. However, this is the first time I use this kind of data analysing tool, and I might do something wrong in the analysis. An eventual error might not be noticed and therefor the result can be misleading.

Similar problem as the ones mentioned above, can arise with the surveys. How good the survey will be depending on my ability to formulate questions and answer choices. There can also be potential problems with analysing the surveys. Getting people to answer the survey can also be a problem, since people tend to forget to answer when they are given the option to answer whenever they like. Another problem with surveys is that the collection of data can be too small to make general conclusions based on, and to get good statistic the experimental conditions must be controlled tightly, often so tight that the findings cannot be used for generalization, a problem mentioned by (Nielsen, 2004). Because of this, my quantitative research will only be used as a complementary research; I do not believe that I will get enough respondents to obtain a satisfactory data foundation. The quantitative survey can be used to see if the findings from the qualitative research relates to each other and thereby this thesis can be used as a foundation for further research.

It can also be an issue with recruiting participants to the participatory design sessions. This requires time and it pushes people a bit out of their comfort zone as most of the potential participants might never hear about participatory design.

The closeness to the participants during the workshops requires decisions regarding how the data will be collected, documented and used, as well as taking their privacy in account. The data must be interpreted in such a way that it is not possible to recognise the participants. (Bergold & Thomas, 2012). Data collected from the workshop can also prove difficult to evaluate and analyse because the output from the participants will be different types of artefacts, not much written material other than my notes. To use artefacts requires that I interoperate them, in this process there is a risk that the artefacts are interpreted in a different way than the participants meant because I have a different point of view.

Ethics are also important to acknowledge, since this research will require that the participants and respondents talking about their own behaviour, usage patterns and other personal elements etc. This is something that the respondents may regard as personal and stressful; to ensure the respondents that their privacy is taken care of every one will get a declaration of consent.

Since the research involves personal areas, I as the researcher must remember that giving advice is inappropriate unless the participants ask specific for advice. Even though I must not get to personal, since that can be considered as invasion of privacy, perhaps not there and then but afterwards when the participants think about the situation.

3.5 Data Analysis

In this section I will describe how I intent to analyse the collected data.

3.5.1 Qualitative Data Analysis

As mentioned in section 3.3 the data will be collected using interviews, surveys and participatory design. The data collected will be analysed and coded into categories using a Computer Aided Qualitative Data Analysis Software (CAQDAS) called Weft QDA http://www.pressure.to/qda/. The reason for choosing this software tool is that it is easy to use and free of charge. Using this software package allows me to code the collected data into categories based upon the topics (but not limited to) used for the interviews guide (section 3.3.1). Based on the coded categories I can perform queries by the use of "And, Or, And Not", this can shed light on a specific element. After the interviews are finished, they will be transcribed and each interview will be stored as a .txt file, one per respondent. By using the WeftQDA software tool and the functionalities, I can examine the findings in correlation to the research questions.

3.5.2 Quantitative Data Analysis

The data collected through the online survey will be analysed using the analyse functions provided by Survey Monkey https://no.surveymonkey.com/ Using surveymonkey.com enables me to use their predefined rules for analysing and comparison answers. However, the problem with quantitative data is mentioned in section 3.4. The qualitative data analysed by Surveymonkey.com will be used to indicate if there can be a potential relation between the quantitative and qualitative results.

3.6 Activity Diagram and Use Case

Activity diagrams was something I worked with in the course "Software Engineering" the spring of 2013 at Østfold University College. Here I learned that activity diagrams are a graphical representation of workflow, and that it is a part of the unified modelling language (UML) diagrams family. In this course, I also learned to use a UML diagram to describe thing that are difficult to describe with words. An activity diagram is suitable for modelling the activity flow of the system by using activities; it provides a high level of understanding the systems functionalities (beneficial for non-technical persons). Such diagrams have more impact on business understanding rather than implementation details (Tutorialspoint.com, n.d.). The purpose of using this type of diagram is to describe and draw the activity flow of the system, based on the results from the interviews and workshop. This will provide an understanding on how the users intend to use such a system as well as identify where the potential for energy saving and energy management lies as well as where the potential for behaviour change is.

According to (Skagestein, 2005) a use case describes a storyline, being a dialog or interaction between actors and the system. An actor can be a person or other systems that interact with the intended system. A use case model describes the interaction on a superior level however; it should describe a complete sequence between the parties aiming to complete a goal. Even though a use case describes the interaction on a higher level, it is crucial that the actor in some way is able to communicate with the system.

The use case should contain all system activities that have a significance to the user it can be thought of as a collection of possible scenarios (Rouse, n.d.-b).The use case are a visual representation of the intended goal, and the main activity is being the goal. They provide an overview of the goal without needing to know the system requirements.

The purpose of using a use case is to get an outside view of the intended system and show the interactions among the goals and actors. The use case will build upon the results from the interviews and workshop; those results will give an understanding of what the goals of the users are.

4 ANALYSIS

This chapter describes how the research was conducted, the interviews, the participatory design workshop and the survey performed. This forms the basis for the activity diagram that is meant to represent the workflow as of today, how today's consumers think about energy, usage and saving. The results from this chapter also serve as a basis for the use cases that will show the tasks considered as important by the consumers.

This chapter describes the findings from the interviews, each of the findings are categorized according to the topics discussed during the interviews.

4.1 THE INITIAL IDEA

By actively involving the users, as well as given the opportunity to gain more control over both technology and consumption the idea was that this would increase the engagement amongst new potential users of the smart house concept. As well as obtaining an insight to how the potential users go about using such systems (the workflow) and identify the potential main tasks (by using use cases). If the workflow and mind set becomes clearer, it is easier to design and propose guidelines that have a greater potential of success.

By making the consumers more aware over energy management and implementing BI techniques, the idea is that this would make them more aware and therefore after a period change their behaviour. Actions in this context were defined as defining and performing individual goals, defining user preferences and create engagement with the use of some sort of motivational incentive. One way of doing this is to provide some sort of reward, goal or competition However; the aim is that a form of reward would not be needed because the underlying behaviour would change.

One way of cater for engagement and behaviour change, is to use the concept of feedback and competition. Another aspect would to provide the users with some form of energy guidance, similar to the one discussed by (Palm, 2010) in his article. The purpose of this guidance is to distribute knowledge regarding different energy sources, energy distribution and energy usage.

Based upon this the proposed solution to the research questions contain guidelines for designing and implementing energy management based upon BI techniques for a smart house concept with the users in focus and having control.

4.1.1 Challenges

Even though smart houses and the related technology has been around for many years, it has yet to reach full market acceptance and potential. As mentioned in chapter 1 the focus for many years has been on technology and this could be a reason for the smart house not being able to reach most of the potential users. In their research (Gann, Barlow, & Venables, 1999) report several reasons for what they believe causes this slow growth, this report is 17 years old however some of the reasons are applicable today.

This indicates that the smart house concept has not improved significant over the last years, when it comes to the consumers:

- Understanding the consumer's needs.
- Consumers in general lack understanding about potential benefits.
- Technological difficulties. (Installing and integrating into the existing household).
- Cost.

Technological difficulties and cost are not challenges that will be covered in this thesis. Consumers needs and enhance the understanding regarding potential benefits are elements this thesis can address. If one gains a better understanding of the consumer's needs, what they actual wants, what knowledge they possess, the chance for developing a solution that are usable, useful and motivational are higher. One way to approach these problems is by using a user-centred approach. A user-centred approach will prove beneficial because most research regarding smart houses has revolved around the technological aspect. This approach will perhaps develop a solution that the consumers will see as valuable.

4.2 THE INTERVIEWS

The respondents consisted of four female and four male respondents (n=8) between the age of 28-47 (mean=33.6, media=30, mode=29). This section describes the findings, and the findings are categorized towards the topics used in the interviews.

4.2.1 Approach towards energy saving and usage

One this topic the respondents almost unanimously talked about how their approach towards energy saving and usage, that it was quite simple; if energy was needed it was used. As one respondent said:

> *… (Laughs) I turn on everything and never think about when I use it. Energy is something I take for granted I guess. If it is cold, I turn the heating up simple as that.*

(R6, female, 29 years).

Another respondent had a similar answer as the respondent above;

> *My approach is quite simple; I use energy whenever I need it. I often leave the light on when I go out from my apartment, a bad habit but I often leave in a hurry and therefore it is easy to forget to turn of the light.*

(R1, female, 33 years).

When asked if they had some idea where the energy was used and if they considered the energy classes of new appliances the answers were quite different. There seemed to be a trend that the older range of participants had a better overview of where energy usage went and considered the energy classes when buying new appliances. However, the energy class was not essential when deciding on what appliance to but, the functions was more important.

..But it was not the energy class that was essential that was just a bonus, the functions of the appliances was most important.

(R3, male, 47 years).

Another responded gave this response when asked if he took the energy class in consideration when using the appliance;

…I do not think that it influences how I use energy, I turn on the appliances I need when I need them, regardless of energy class.

(R2, male, 31 years).

When asked if they had considered utilizing technology one participants said that:

Well, in periods, I think a lot about energy and how I can reduce my usage, how technology can be used, how I can use technology and such. So, even though I think about using different forms of technology for controlling/reducing energy usage the thought itself has had little influence on my daily life.

(R7, male, 43 years).

4.2.2 Where the energy is used

As the section above shows the respondents have a simple approach towards energy saving and usage. With this in mind, the participants were asked if they had an idea where the energy is used given their simple approach.

When asked where they thought most of the energy was used today, one respondent gave this answer;

I have no idea actually. My boyfriend pays the electricity bill and as long as he does not complain that the bill is to high I don't ask. Bad habit I guess, leaving it to him.

(R6, female, 29years).

Another respondent gave a similar answer. He mentioned that he is interested in energy but as long as the bill was low, he did not care where the energy was used.

Hmmm, I am not sure, heating perhaps? And washing machine/ dishwasher? As I said, I am not sure (laughs) quite embarrassing for some one that is interested in energy and savings. (laughs). I must say that I am quite happy if the utility bill is not too high and therefor I have not thought too much about where the energy goes.

(R2, male, 31 years).

The other female respondents all gave the same answers to where they thought the usage went, either heating and/or light or dishwasher and/or washing machine.

Heating, light and general appliances (tv, pc etc.)

(R1, female, 33 years).

Hmmm, washing machine and dishwasher perhaps? I use them a lot with three kids (laughs).

(R8, female, 28 years).

The male respondents had the same opinion on where the energy was used and what they could do to lower their usage.

> *I: Where do you think most of your energy is used today?*
>
> *R: Heating, no doubt.*
>
> *I: Have you considered making some energy saving actions?*
>
> *R: Yes, I have thought about replacing the windows, but they are actually not that old (10-15 years) and it costs a great deal. But, yes I think replacing the windows can be something that would keep more heat in.*

(R7, male, 43 years).

> *I: Where do you think most of your energy is used today?*
>
> *R: Since we live in an old house, much of the energy is used on heating. To reduce the electricity bill we uses the fireplace as much as possible.*
>
> *I: Is it a big house?*
>
> *R: No, it is not much over 100 square feet. So we invested in a big (for our house that is) fireplace that can heat up the entire house. We do not have a second floor so it gets warm her in the winter with the fireplace*

(R3, male, 47 years).

4.2.3 Energy management and decision support

When it came to energy management the participants were asked if they wanted to use the latter, if it could help them to reduce their costs and usage. The general opinion amongst the participants was that if it was not too difficult they would consider using it. With that said, if it was not too time consuming or difficult.

> *That depends on how it is implemented and what tools I would have to use. If it would be something like a flowchart for example or a method, I would have to learn I think it would be to boring and I would lose interest pretty fast. However, if it was easy to use and did not require that I learned a method or something then I would perhaps consider it. If it is too difficult and time consuming I do not think I would consider it, despite it being fun and could save money.*

(R2 male, 31 years).

> *Well, yeah I think this is something I could try to use /learn to use. However, if it is too time consuming or difficult it would take a lot of convincing before I would use it. If it is easy, then yeah I would try to use it.*

(R5, woman, 29 years).

Both participants above show the general opinion amongst the participants; however, Respondents1, female, 33 years mentions one important element;

> *It depends on how easy it would be to use. If it requires a significant load of work each day I do not think this is something I would consider.*

When it came to decision support tool in combination with energy management the general opinion amongst the participants was that it would be something they would consider. However, as with energy management such a tool must not be time consuming or difficult, as stated by Respondent 1 (female, 33 years);

> *Yes, that would be something I could consider to try, perhaps not where I live now. But when I get a house for example then such solution is something I would consider. But then again, it depends on how difficult and time consuming it is to use.*

Another respondent had a different point of view on the topic of decision support;

> *Something that I would have to use my mobile or pc for that would tell me what would be a good decision? Yes, that I would use. But it would perhaps feel like "big brother" is watching you, I mean your pc tells you what is good or bad. Should not I be able to know this for myself? (laughs).*

(R5, woman, 29 years).

4.2.4 Motivation and incentives

One topic that came up often when motivation and incentives for saving was discussed was money. As one respondent put it;

> *Except from money? I don't know, I mean, money is what motivates most people isn't it?*

(R2, male, 31 years).

However, another respondent had a different point, as with the respondent above, money was an important factor.

> *First of all, the reduction or saving would not have to affect our comfort. Saving money is never wrong or saving the environment.*

(R3, male, 47 years).

A similar answer was given from respondent 5 (woman, 29 years);

> *Some sort of reward. Money, reduction in bill, a gift? Something that would make me feel like I have done a good job.*

The topics which was recurring were money and reduction in utility bill, and some participants talked about the fact that they wanted to feel like they had done a good job.

4.2.5 Feedback, Displays and behaviour change

On the topic of feedback, visual displays and behaviour change, the respondents had different views and answers. One recurring topic was that feedback could be used for keeping motivation up, however as respondent 3 (male, 47 years) answered;

> *A visual display might be a good help for remembering to reduce. But like so many other things I think after some time it would just be forgotten. But as visual aid I think it wold be great.*

(R3, male, 47 years).

This was also a topic respondent 5 (female, 29 years) talked about, she also mentioned that such a display and feedback in combination with energy management planning could lead to her changing her behaviour;

> *In the beginning, I think that I would use such a thing often. But after a period I think that it would get boring and a would forget to use it? But then again by then I might have learned and understand the energy management and started to work on changing my behaviour.*

(R5, male, 29 years).

Another important element mentioned by respondent 7 (male, 43 years) was the element of teaching children the importance of saving energy and thinking about the environment.

> *I think that a visual display would be great, that way I could keep track and also show the kids what/where the energy is used and how much it costs. Teaching the kids to think before they turn the heating up, and when it is too hot open the window (without turning the heating down). A visual display would serve as a great supplement for teaching in our house.*

(R7, male, 43 years).

Another respondent also mentioned the topic of children;

> *Like a little TV or tablet on the wall? That would be great because then me and the kids would always see it and it would be easier to remember to turn off the lights when we go outside etc.*

(R8, female, 28 years).

Respondent 6 (female, 29 years) had a similar answer to the one from respondent 8. Respondent 6 addresses the topic of teaching children about energy usage.

> *A display I think would be better because it would serve as a visual aid and therefor reminding our family to change our usage/habits. And also helping us understanding energy management, what we are doing and why. It would also perhaps be easier to explain to our child why we for example must remember to turn off the light in his/her room when no one is there. So in that way it could teach the child and ensuring that he/she in the future thinks about the usage and has the tools for changing the behaviour if it is needed.*

(R6, female, 29 years).

4.2.6 Information and data

The aim of this topic was to get more input on what the respondents thought of as important information, what kind of information they wanted to see and use for decision-making. Respondent 1 (female, 33 years) answered this when asked what kind of information she wanted to see in a smart house information system;

> *As I said before, the same graphs all the time would get pretty boring. There are of course basis information required but different information would be nice. Different information during the different seasons of the year and such.*

(R1, female, 33 years)

However, other respondents had a different opinion about what sort of information they would like to see. Information about money, energy usage, energy waste, appliances in an easy to understand way seemed to be what most of the respondents wanted.

> *I would like to have information about my usage, saving, where most of the energy has been used like in what room, appliance etc. how much money I have spent, yeah that kind of stuff. Perhaps an interactive map of the house or something would be fun?*

(R7, male, 43 years)

Some of the respondents on the other hand had an idea of other elements they regarded as beneficial to a smart house system;

> *Reminder to pay the bill! (Laughs) and to read of the meter. Where the energy is used perhaps, so that I can be better to turn off the lights and stuff*.

(R4, male, 29 years)

> *Information about the appliances, how much they use and how much it costs. History perhaps? Charts and thing like that to visualise. Reminders would be nice, like when leaving for work a reminder could be; have you remembered to turn off the lights and the heating?*

(R3, male, 47 years)

4.3 The Workshop

This thesis involved participatory design workshop with potential smart house users. The results from this workshop will form the basis for use case, activity diagram and the earlier mentioned survey in section 3.3.3.

4.3.1 Participatory Design Workshop

As mentioned in section 3.3.2 participatory design sees the world from the user's perspective, which allows me as the researcher to get insight into information, feelings etc. that the participants might not be able to put into words. A collaborative setting such as a workshop allows the participants to be more playful and use their creative sides, this again makes the setting less frightening and unknown. (Sanders, Brandt, & Binder, 2010) proposed a framework that provides an overview over the different tools and techniques for engaging the participants in the workshop activities. They talk about the different variables one should consider when planning a workshop. Such as group size, face-to-face or online and where to conduct the session. A list of examples of different tools and techniques, where they are applied and in what context they will be best suited as well as their purpose is also provided. The activities are divided into three activity groups (making, telling and acting) with the aim to engage the participants, (Sanders et al., 2010) suggest that the three activity groups should all be used in a workshop for obtaining the optimal workshop and for preparing the participants.

Based on the insight from (Sanders et al., 2010) I decided to form a small group and arrange a workshop. The goal with this workshop were twofold: The first aspect was to engage the participants through different activities, with the aim to generate different design ideas that the participants believe would be ideal for saving energy (with the usage of Business intelligence /Business analytics and energy management) as well as altering behaviour.

The second aspect was to identify different problems that the participants address on a regular basis and to get an insight in their general workflow regarding energy usage.

This information will be used to see if the proposed problems can be solved with the use of BI/BA and energy management. In addition, identify places where the participants considered themselves as happy, and to empower that emotion with behaviour change in mind.

The workshop was divided into two activity phases; making and telling. As mentioned in the section above (Sanders et al., 2010) suggest three activity phases, since I have no prior experience in participatory design workshop except the one I participated in the fall semester 2014 in the course "Interaction Design" at Østfold University College I therefor decided to use two phases.

The making phase would be used to see how the participants though about energy, behaviour and emotions, thence linking the response towards energy management and behaviour change. The telling phase would then be linked to the more practical, well known element, user interface and interactions. The results from the last phase would potentially provide my research with information that can be linked towards business intelligence and how that can be used in combination with energy management.

The last phase however would also contain a discussion and trying to get the participants to envisioning themselves using the solution, a concept mentioned by (Sanders et al., 2010) as a part of the third activity phase. During the "making" phase the participants was provided with a timeline sheet (see figure 5, scaled down) simulating a week, then they were given different cards with emotions (happy, sad etc.) see figure 4 (scaled down), situations (child turned on heating and forgot it, charging the car etc.) and blank cards that they could define themselves (weather, bad economy etc.). This phase was about trigging the different emotions, getting the participants to think about their interactions with energy appliances and making the goal of the workshop more tangible. In this exercise, the participants mapped different situations on different feelings. For example, the child forgot to turn off the floor heating triggered the emotion face card "angry". The blue lines in figure 5 "Positive, Neutral and not satisfied" were drawn in as a guideline to the participants.

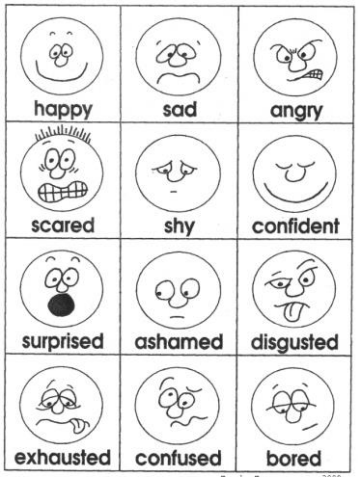

Figure 4 Emotion faces (Peterson, n.d.)

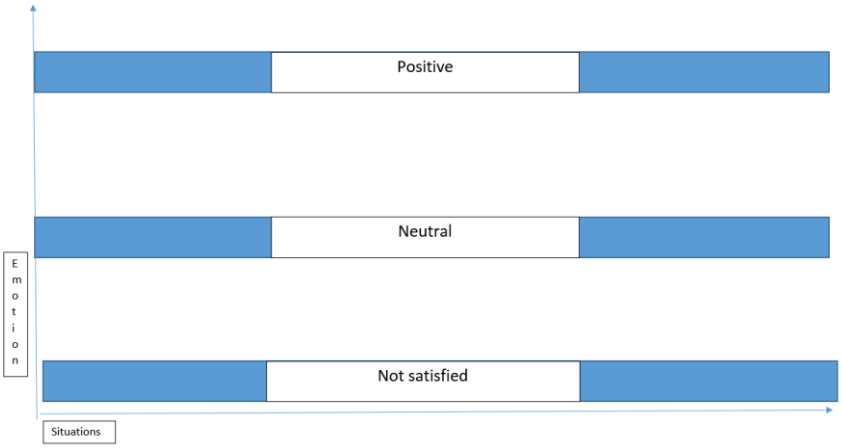

Figure 5 Timeline

The “telling” phase included a storyboard exercise and a wireframing exercise. This is a form for low-fidelity prototype witch encourage the participants to sketch the design of their dreams. It also makes the participants think through content and functionality; this also made me see how the different users thinks about problem area.

The participants also received different paper cut out icons (mail, alerts, trophy etc.) that they could use in the wireframing exercise. The storyboard exercise made the users think about how they would interact with the solution on a day-to-day basis (workflow).

Before the workshop activities started, the participants got an introduction on what the goal of the workshop was; getting the users more involved in the smart house concept and communicate their needs and requirements. The participants were asked to read through and sign the declaration of consent (appendix 5). They were provided with blank paper sheets, crayons, pencils, post it notes and stickers witch they could utilize if they felt the need for altering or add their own contributions. During the workshop, I had the roles as the observer and the “instructor”, even though this was a dual-role arrangement the roles did not interfere with each other. The participants would get instruction on the task and after that I would observe and take notes. Participants were three students from the college university; none of these students had first-hand experience with smart houses so they got an overview of the concept before the workshop started. I created paper based timeline template and storyboard template both in A4 size, which the participants filled in and altered to suit their needs. Figures 6 and 7 (full-scale picture can be found in appendix 5) shows the wireframe and storyboard used (scaled down). As figure 6 shows the template is of an android phone currently on the market, the only difference is the size, as previous mentioned. To get the participants started I sketched one proposal of the user interface, ensuring that they had a starting point.

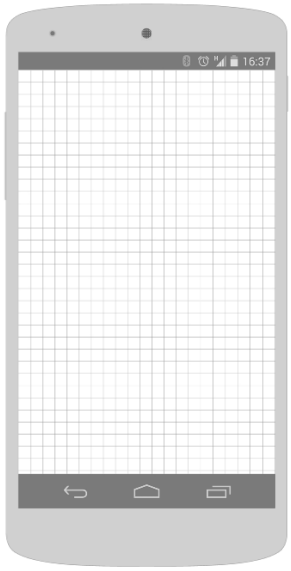

Figure 6 Wireframing template from (Bocquelet, 2014)

Figure 7 Storyboard template from (balsamiq.com, 2014)

4.3.2 Summary of the Workshop

After the first activity, the uses identified that they had the will to change their approach towards how they use energy when they got the utility bill or had some sort of negative experience with usage. When asked if a positive experience wold have an impact on the usage, they responded that it would give a “good feeling there and then” but it would rapidly be forgotten. When talking about the timeline and the emotions it was agreed that the participants easily got back into old habits and one suggestion was that it would be needed resources for preventing this. Some sort of reward system was proposed, however this was also identified that perhaps would be insufficient and the users would fall back into old habits after a period. One participants talked about the need for “catching” the users in the right moment before they fall back into old habits (add stimulus for preventing fall back). The same participant also proposed that each user finds out what motivates them to change, identify what can serve as a trigger. However, the participants all agreed on that saving money is an important motivational and behaviour change factor. Another participant talked about the concept of gamification, making the saving and changing as a game, this was discussed amongst the participants and they pointed out that gamification could have a positive impact but the problem was to make it “fun and games” for a longer period and keeping focus on what is important.

They then proposed that the emotions faces used in the activity could be used, because they are easy to interpret and understand for everyone, regardless of the age group. They also pointed to the fact that the faces could be used for competition within a family for example. It was also identified that when participants felt happy and content they did not feel that change in behaviour or energy usage was needed.

In the second activity session, the participants were asked to design their ideal information system interface by use of wireframes. As well as try to visualize a situation in the future (by the use of storyboards) where they used their ideal interface and try to put in word what potential influence this would have on their lives. During this session the participants did not use my suggestion of interface, at first they started drawing their own suggestion however after a short time they started to collaborate with each other. The participants felt that one well though trough suggestion was better than three individual suggestions, which in the end all would have looked similar. They did not think that it is possible to design "one size to fit all", with that in mind the participants then proposed three user groups that identified as the main groups for this information system.

When the participants came to the storyboard activity, they designed one storyboard each. The participants were given a scenario (see appendix 2), based on that and their personal experiences they draw storyboards. As a results from the storyboarding activity the participants identified some elements they would have in an energy information system. When the participants were asked to visualize themselves using their proposed information system (based on the wireframes and storyboards) it became clear that even though this was a small group I could identify different approaches towards energy saving and usage. One had the approach of only utilizing the proposed system when it was needed (after the bill had been received in the mail) and only identified where the usage had gone. The second one imagined that after the bill was received the system would be used in combination with discussion with the significant other. The third participant had the approach of imagine that all unnecessary appliance would be turned off and looking at how much energy and money that was saved (money was mentioned as the most important).

Common to all the participants were that they all wanted lower utility bills without it having an impact on their comfort. After the activities was finished, the participants engaged in a discussion related to the workshop and related topics. The participants identified that regarding analytic functionalities they wanted to see information regarding consumption, pattern of usage and decision-making. They did not reach a common decision when discussing if energy management or analytics was the most important functionality, they mentioned that it was difficult to decide what is most important because of individual preferences. When discussing the aspect of change, they agreed on that some form of altering motivational factor could prove beneficial, one participant mentioned several ideas such as; Scrooge McDuck's money bin to indicate money saving, happy/sad mother earth to represent the environmental aspect, the rainforest and penguins. Another participant also mentioned the aspect of adding personal motivation; saving money for example to buy something one wants (a reward aspect). When talking about what basic elements they wanted covered something easy to use, shows relevant information for that user, considers personal comfort level and needs was the key elements mentioned. Visualisation was mentioned as a form of providing feedback, as one participant mentioned; almost everything regarding feedback has been done so why not just use something that works. However, the participant thought the idea of feedback based on the seasons of the year sounded interesting, if it showed relevant information for them.

4.4 THE SURVEY

The aim for the survey was to address the topic of how smart house concept in combination with energy management and analytics could change the behaviour. As well as collecting data regarding the general trends when it comes to energy usage, consumption, habits, motivation and technology. As well, validate or discard the findings from the workshop and interviews.

The surveys were open for answering March 16, 2016 to March 30 2016. The results from the participatory design workshop provided input to what topics the surveys should cover. Because surveymonkey.com have a limitation on 10 questions per survey (more than 10 questions required a PRO account) therefore I used two surveys. The topics in the first survey ranged from age groups, type of living accommodation, feelings regarding usage/high bills, if the respondents noticed trends in the utility bills regards the season of the year, if they had used smart house functionalities before, what they thought about the functionalities if they had used them. The second survey looked at behaviour towards saving, if the respondents would consider using some form of energy management, user profiles and analytics if that could lead to reduction in usage and bill as well as what the respondents were motivated of.

As mentioned the survey was open for 14 days, it was distributed through Facebook and Snapchat. The use of social media was chosen because I have had poor response on surveys distributed on mail in earlier projects.

Snapchat gave me the opportunity to add the links to “My story” so that people would be reminded on the survey every time they looked at “My story”. The use of Facebook was chosen because I believe that the survey then would reach the “average” user of technology etc. If I would use LinkedIn.com, the survey would be answered of respondents with high knowledge of technology and energy, because my LinkedIn network consists of that kind of people and those people are not the “average” user.

The surveys received 27 answers, considering the fact that it was distributed right before the Easter holiday I do not consider that bad. Surveymonkey.com analysed the results, and provided me with different forms of diagrams, how many answered the different questions in percentage as well as comments from the respondents. One aspect I wanted to investigate further was whether women or men are most interested in consumption etc., unfortunately because surveymonkey.com has a limitation to 10 questions per survey I did not want to create a third survey.

The aim of this survey was to see if the results from the workshop correlated to a larger group, and to get more background information to the development of the activity diagram. Unfortunately, with the survey, it did not get as much response as I wanted so there for the results cannot be generalized. However, some of the results correlates with the literature review; motivational factors, the adoption of smart house technology and the “driving in the dark” approach regarding the utility bills.

4.5 Activity Diagram and Use case

The activity diagram builds upon the results from the interviews and the workshop, the aim of this diagram is to make it more clear what decisions, actions and activities the users might do. It also can help to identify where there is need to support the users so that they do not fall back into old habits. Since the interviews are analysed with the use of a textual analysis tool it is easy to identify the requirements and activities from the different texts. This information was also used for developing use case for displaying user behaviour and the goals in the proposed system.

4.5.1 Use cases

Below in figures 8 through 11 (larger pictures can be found in appendix 5)**,** is the use cases developed on the information mentioned above. The use cases contain the general opinion amongst the participant regarding what they consider as the most important goals on the different areas in this thesis. As one can see in the use cases, the goals are not revolutionary; this is because when it comes to what consumer's wants of such a solution it is already recognised by the energy industry.

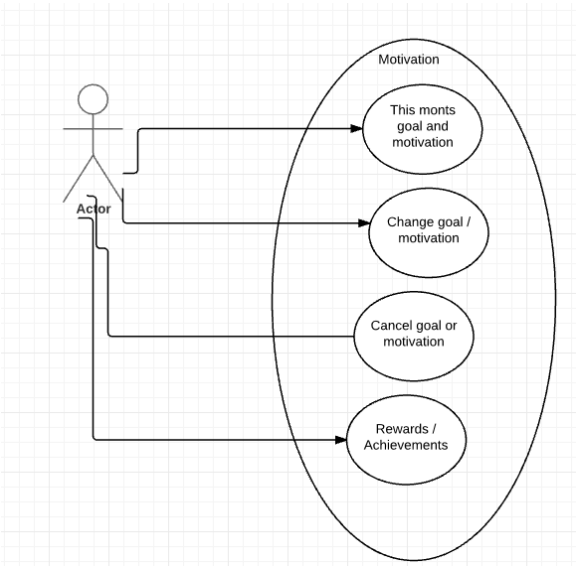

Figure 8 Use case "Motivation"

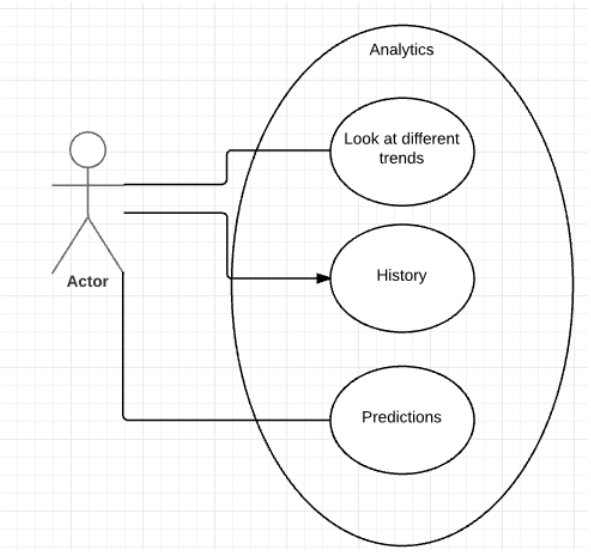

Figure 9 Use case "Analytics"

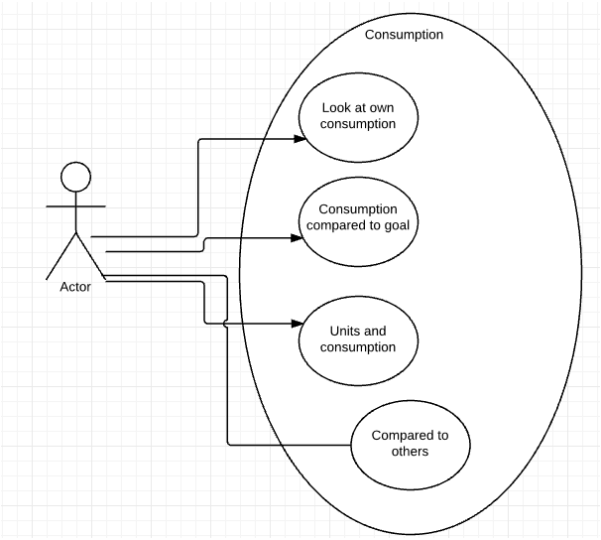

Figure 10 Use case "Consumption"

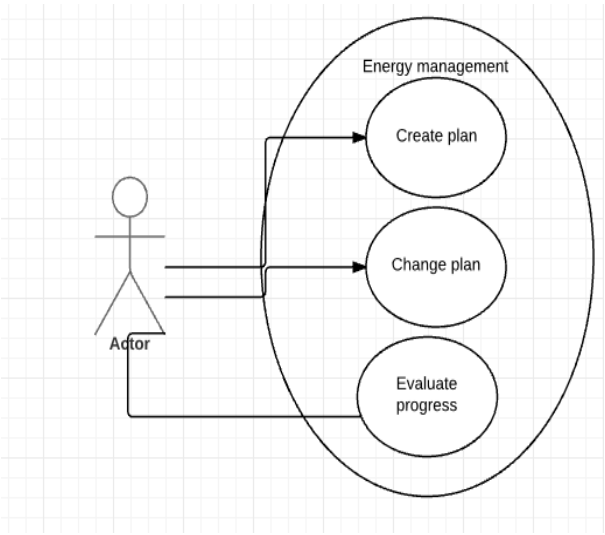

Figure 11 Use case "Energy management"

However, the use cases “motivation” and “energy management” contains goals that can address the subject of behaviour change and energy management. In addition to creating and changing the energy management plan, the need for evaluating the progress can prove beneficial.

This can help to keep the motivation, and if a change of plan in needed that can be done. If the consumer can change their plan if something comes up this can be done, and that will ensure that the motivation will not be lost because the consumer still can reach their goal. As mentioned by one participant in the workshop, some kind of gamification could be positive. This is also recognised by (Dale, 2014) in his article, one of several articles on the subject as well as two master thesis on the subject from (Du, Feng, & Zhou, 2014; Kaczmarek, 2015). As gamification is not a part of this thesis the concept, such elements are not evaluated. However, as an element for keeping motivation for behaviour change a form of reward are considered as beneficial for the users.

4.5.2 Activity Diagrams

The activity diagram in figure 12 (larger picture can be found in appendix 4) shows how the participants explained their activities and decisions regarding the aspect of receiving the utility bill. As explained in section 4.2.4 most of the participants in the survey answered that they just pay the bill or gets irritated when receiving a higher bill than expected. Very few of the participants discussed the utility bill with someone else in the household and developed a plan for saving.

The participants from the workshop also identified the processes in the activity diagram; however, they also mentioned that the will to change came with a negative experience. The key is to take the negative experience, turn it into something positive, and continue to build upon that. The activity diagram provides me with an overview of the activities and where the respondents identified that there was need for support. For taking good decisions and planning their usage.

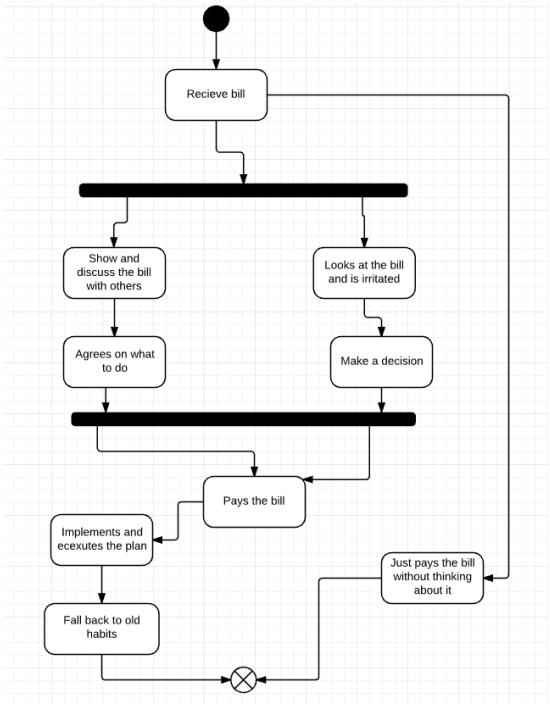

Figure 12 Activity diagram

4.6 In Summary

In this chapter the results from the interviews, workshop and survey has been presented as well as the use cases and activity diagrams. The purpose with the interviews was to obtain a deeper insight in what potential users thought about the topics in the interview guide. The general trends were that the approach towards energy usage and saving was quite simple, if it was needed it was used. The respondents also explained that appliances and units was often turned on and left on, no one remembered to turn them off again. Another trend was that it was the men that had most interest in energy in general, the woman left those matters to the men.

The aim for the workshop was to gain input on what functions and analytics the potential users could want in such a smart home information system. To do this there was conducted different activities with the aim of getting information that one might not get during an interview. The results showed that the participants thought there was a higher chance of change when there was a negative experience.

The participants pointed to the fact that a sort of reward would be required; this is also something that the literature in section 2,4 and 2,5 from (Abrahamse et al., 2005; Zipperer et al., 2013) showed. The results showed that the users' needs the possibility to personalize the motivation, to make it more personal, in addition to a predefined motivational goal. When it came to the design, the participants believed that it would not be possible to develop a design, which would be suitable for all the user groups. Based on this the participants came up with four main user groups, one design for each main user group would be required according to the participants. By doing this the participants believed that it would be possible to make the motivation and incentives more personal and the information would be used more active and led to change. It was also proposed that children received more attention because they are the next generation and needs to be educated.

The results from the survey somewhat correlated with the results from the workshop and interviews as mentioned in section 4.5.1. The key elements to note is the motivational factors, adoption of smart house technology and the "driving in the dark" approach when it comes to energy saving and usage, especially amongst the females.

5 PROPOSED GUIDELINES AND METHOD

When I first started this thesis my envisioned idea just involved the users in the smart house environment, after the research was completed it became clear that the designers and developers needed to be a part of the solution. Because of this I developed a set of simple guidelines to ensure that the parties that develops the smart house solutions will include the users more, with the aim of ensuring user confidence.

If the users in the smart house environment shall be able to gain more confidence and the adoption of smart house concept increase, the designers and developers need to have some guidelines. These guidelines correlated with the proposed method, and as such aims for increase in understanding and confidence. The guidelines ensure that the designers obtain a better understanding of the users and the method aims at providing more user confidence and change in behaviour towards energy.

Based upon results from interviews, survey and workshop a method with the aim of ensuring user confidence and personalization when it comes to energy management and planning a method and guidelines were developed. Smart house systems are used to fulfil a task and needs, and it is important to identify those needs and tasks in order to develop the right system. When developing and designing an information system that will meet the user's need it is important to understand who the users are and aren't. The earlier mentioned research results in this chapter showed that three main user groups were proposed with the aim of customize and ensuring user confidence as well as behaviour change. The method proposed in the next sections aims to ensure that the latter is recognized. These proposed guidelines are based on the use of primary research (interviews etc.) and secondary research (from the literature review).

5.1.1 Guidelines for energy management planning for reduction and behaviour change

To adapt the proposed approach of implementing Business Intelligence and energy management in order to contribute to energy management or a higher level and encouraging behaviour change, guidelines has been developed based upon results from the research. These guidelines have been developed with the aim of ensuring user confidence in the smart house environment and understanding what the users want.

5.1.1.1 Step 1: Defining the environment and interactions

In this step the designer has to define the environment of the information system. To ensure that it is as customized as the research showed the user wanted such a system, some parameters are important to acknowledge.

- Household size,
- Family type (According to the groups from the workshop),
- Daily activities (Activity diagrams)

5.1.1.2 Step 2: Defining user needs

This step is important because when designing a smart house concept with the aim of enhancing user confidence knowing what the users' needs are important. In doing this the designers know where the user comfort zones are for example. If the needs are not known the right thing cannot be developed.

- Comfort zones,
- Daily recurring interactions with energy,
- Use cases (what the users thinks is the most important tasks)

5.1.1.3 Step 3: Identifying motivation

The research showed that one element that was acknowledged as important was the motivation. Analysis of the results showed that the participants and respondents wanted the possibility to personalize the motivation, set personalized goals as well as goals and motivation that is a part of the bigger picture (reducing carbon footprints for example). Therefore, it is important for the designer to identify both personalized motivation and goals in order to reinforce behavioural change and change in habits.

5.1.1.4 Step 4: Defining what information the users want

In addition to the predefined information, like energy usage and savings, impact on the environment and such. The research in chapter 4 showed that potential users also want to define some of the information that can be displayed. This is something the designers need to take in account and developing a way of extracting what information that specific user wants to see and use. By doing this the smart house information system can be tailor made to suite the individual users, this again can lead to the users actually using the information system more and changing their behaviour and habits.

5.1.1.5 Step 5: Plan for executing

As the research showed, some of the females in the interviews talked about the importance of involving the children with the aim of providing them with a better foundation of energy management for when they get older and moves for themselves. In this step it is important to make a plan for how to develop a design that will involve the potential users in the home. It is important to define what is an acceptable flexibility when it comes to involvement, motivation and implement room for errors from the users.

- Focus on user experience: Effectiveness and efficiency, learnability, usefulness

5.1.2 Method for user confidence

Based upon the analysis from the research in chapter 4 and the literature review in chapter 2, a method was developed for ensuring user confidence and energy management planning. The aim for the users when utilizing this method is that the behaviour will change, and taking a more active approach in how they use energy. The aim for this method is making the users feeling confident, engaged, motivated, helped, as well as helping them to identify their goals, motivation, what information and feedback they want. The method and the proposed guidelines will complement each other.

The method is displayed in figure 13.

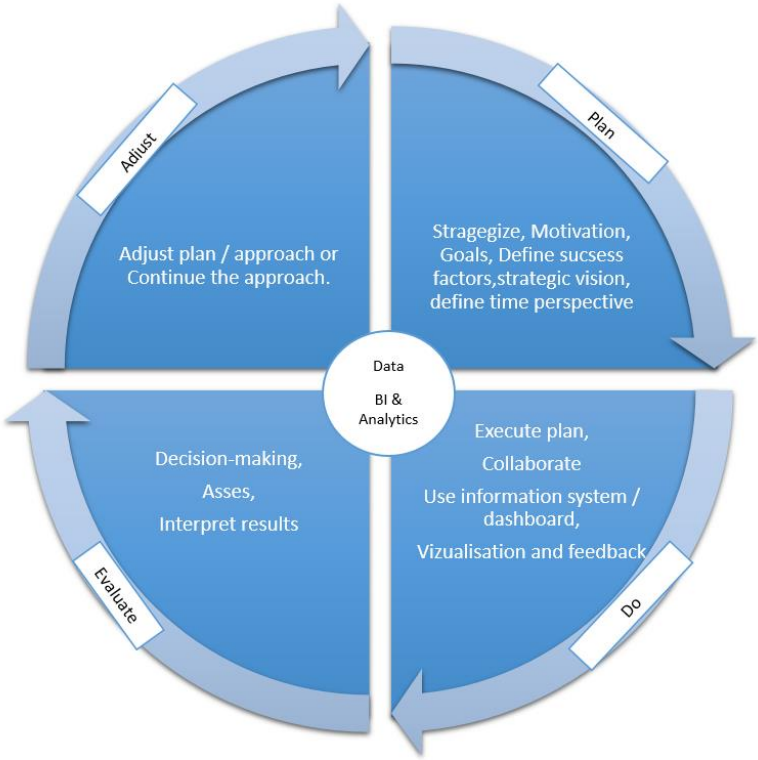

Figure 13 Proposed energy management method

This method focuses on change and planning; the inner circle represents the underlying data that the method utilizes. This method is to be used both as a mental model and a function in the envisioned information system. This model emphasises the individuality of the user.

Plan: Here the aim for the user is to identify where they want to go and what they want to accomplish with regard to their personal energy usage. As well as plan how they get where they want to go.

Do: The aim in this step is that the user executes the plan from the step above. With the assistance from the smart house information system.

Evaluate: In this step the users shall evaluate how the plan and process is going. Evaluate the decisions against desired usage and pattern of use.

Adjust: With the results from the latter step the users can then decide if they will continue the approach if that is desirable or if it is needed to adjust their approach in order to meet their goals even better for example.

This method in combination with the guidelines in section 5.1.1 is based on the results and will potentially make the users feeling more in control, engaged and motivated for energy management and energy saving.

5.1.3 Fit in the current smart house concept

In figure 14 below shows an overview where the proposed method will fit into the smart house concept along with all the other features one might add.

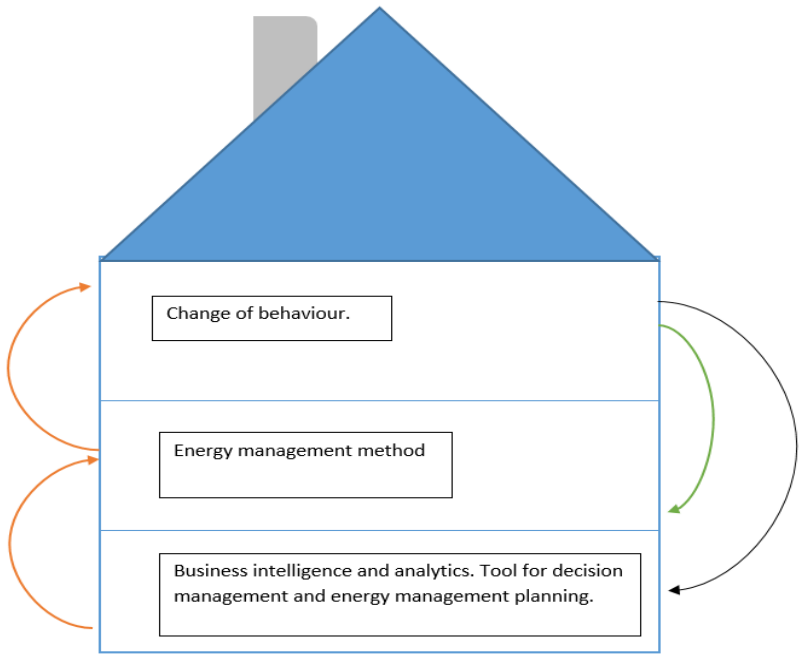

Figure 14 Smart house with proposed method

The lower part of the house represents the technical aspect, where data is being processed, changed and analysed according to predefined settings, from both the user and the system developer, what sort of BI tools proposed used is shown in table 1 in section 6.1. The middle part of the house represents the energy management planning method as shown in section 5.1.2, and the top of the house represents where the potential behaviour change will occur based on the two latter elements. This is the part that requires the user to manage to evaluate themselves, is the change going in the right direction or am I going back to old habits. Hopefully the earlier two part of the house have provided sufficient support, help and planning so the desired change has occurred. However, some changes will occur every year, like summer turning to autumn and winter, this requires the user to change their approach towards usage.

6 RESULTS

This chapter builds upon the literature in chapter 3 and the analysis from chapter 5.

6.1 KEY FINDINGS

The research conducted in chapter 4 provided some key findings when it comes to how business intelligence and energy management could be incorporated into a smart house concept with the aim of changing behaviour. The results presented here came from the interviews, workshop and survey.

When it comes to the part of motivation three findings were identified as important:

- The need for tailoring and defining personal preferences
- The desire to personalize the motivation aspect of such an information system
- The desire to define personal goals

The workshop participants identified three main user groups they considered as relevant, as mentioned in section 4.3.2, the participants did not believe that it was not possible to develop one information system for all user groups. The reason for proposing different groups was that the participants identified the need for tailoring such a system to the individual needs.

This to some extent correlates with the analysis from the interviews, where it became clear that it was mostly the females that identified the importance of teaching the children the importance of thinking about energy usage and saving. The three user groups identified was:

- Households with children / teens
- Households without children
- Single

The participants choose to focus on children because they are the next generation and given the fact that the population on the earth is increasing and the load on the net is increasing as well the next generation need the tools and experience to handle such situations. This was also an aspect mentioned by the females in the interviews.

The workshop also showed that when the participants worked with the task with timeline and emotions and the task of identifying interactions with energy and the correlating feelings, they acknowledged that it was easy to fall back into old habits and something was needed to prevent that from happening. A form of reward system was proposed as well as the need for “catching” the users before the fall back into their old habits. The concept of gamification was also mentioned, as well as using emotional faces with the aim of addressing the feelings of the users, because they are easy to interpret and understand for everyone, regardless of the age group.

The analysis of the interviews and workshop showed some general trends to what the participants identified as important in an information system in a smart house if the system would be used:

- Analytic functions
- Information regarding usage and saving
- Support for decision-making
- Help with energy management planning
- A system that could provide answers to why the usage “is the way it is” and “why it was that way”. Some form of historic and analysis.

- A solution that could be used both actively and passively, something that could be there to "look after", but the premises of the user's.

The participants in the workshop and respondents in the interview emphasized the fact that it must be possible to define and alter as much as possible, but not everything.

The respondents in the interviews had different suggestions to what sort of information and data they considered as important in such an information system, however the answers from the respondents did not provide any new information. The element the respondents found difficult was to identify what information that potentially could lead to more involvement in energy usage and saving. The only suggestion from the respondents that could potentially led to change was the element of reminders: to turn off the lights, pay the utility bill etc. Moreover, the answers in interviews however led to identifying what types of BI tools that could be used for making the consumers more aware over their daily energy management, see table ZZ.

As the table 1 below shows, based upon the interviews, workshop, use cases and the activity diagram, two forms of business intelligence tools were chosen that could potentially be incorporated in the smart house concept: Online analytical processing (OLAP) database and data mining.

Tool	Function	Input	Output
Online Analytical Processing (OLAP) database	Support decision making. To help with energy management planning. Problem solving. Enable the consumer to extract, view and analyse data and compare.	Data about usage, time, date, appliances, type of family, number of children Nord pool spot prices (http://www.nordpoolspot.com/Market-data1/#/nordic/table), Weather information, Historical data	Report and status tracing
Data Mining	Identify patters and provide an understanding of the actions performed by the consumer. Discover knowledge from the data. Identify relationship between	OLAP database	Predictions, Forecasting, Association,

Table 1 Business intelligence tools

Those tools could provide the consumers with information regarding the energy usage, hence making them more aware and then start planning and thinking more about what, how and when they use energy.

The research conducted in chapter 4 showed that most of the respondents did not know what energy management was, or had even heard of the term. During the interviews, it became clear that almost all of the respondents had a simple approach towards energy usage and saving; there was no planning involved. The utility bill was often left to the men and the females had a laidback approach. This again led to the females not taking an active approach towards energy related topics. This can be traced back to the traditional roles in a home; "the man pays the bills and the woman cooks dinner", to put it simply.

However, some of the females acknowledged the latter and gave the impression that they tried to improve their approach, mostly because of their children and they as moms felt the need to teach their children to be responsible regarding energy usage and saving.

When the respondents were asked if they wanted to use energy management planning as a method, most of them were open to try it if it was not too difficult or time consuming. Energy management in combination with a decision support tool was also something the respondents were interested in, however as with plain energy management method; only if it was not difficult ore time consuming.

The results from the workshop showed that the participants identified that that they had the will to change their approach towards how they use energy when they got the utility bill or had some sort of negative experience with usage. When asked if a positive experience wold have an impact on the usage, they responded that it would give a “good feeling there and then” but it would rapidly be forgotten. The participants also proposed that each user finds out what motivates them to change, identify what can serve as a trigger. However, the participants all agreed on that saving money is an important motivational and behaviour change factor. It was also identified that when participants felt happy and content they did not feel that change in behaviour or energy usage was needed.

6.1.1 Behavioural Change

When it comes to behavioral change the analysis of the interviews showed that the usage of feedback and displays was the visual aid ha the respondents were most positive towards. The key however is to keep the motivation up and the usage of the display active. When it came to what sort of data and information the respondents considered as important there was nothing revolutionary new.

In the workshop, the task where the participants would visualize themselves using their proposed system resulted in different approaches and results. One approach was to utilize the proposed system only when it was needed, another approach was to utilize the proposed system in combination with turning off all unnecessary appliances. However, common for the participants was the desire to lower the cost of the utility bill without it having an impact on their comfort.

The aspect of motivation received quite similar response during the interviews, the workshop and the survey. The general trend in the latter was that money were regarded as a high motivational factor as the figure 15 shows, from the survey.

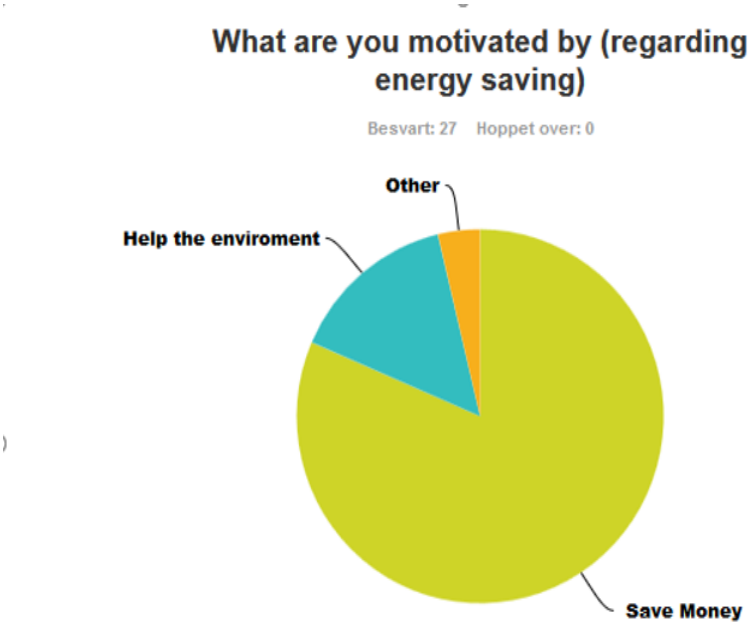

Figure 15 Survey - what are you motivated by

The will to change their approaches towards energy usage and mind-set when receiving a high utility bill was a question in the survey and the answers can be seen in figure 16.

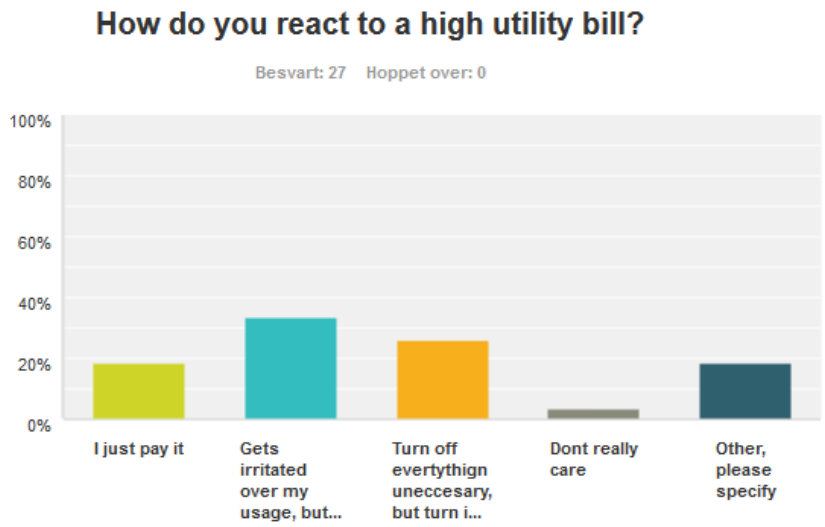

Figure 16 Survey - reaction on high utility bill

As the figure 16 shows, most of the respondents in the survey answered that they did get irritated by over their own usage but did not do anything about it, this was also something the workshop and interviews showed. The answers in figure 16 also acknowledges some findings from the interviews and workshop regarding changing the consumption and after a while returning to their old habits (the question regarding “turn off everything unnecessary, but turn it on again after a short period”).

The survey also showed that 40% of the respondents did not think about the utility bill, which correspond with the findings from the interviews where mostly females leave the bill to the men and finding from the workshop.

In the workshop however, the participants acknowledged that it was mostly during the winter and autumn that they thought about the utility bill.

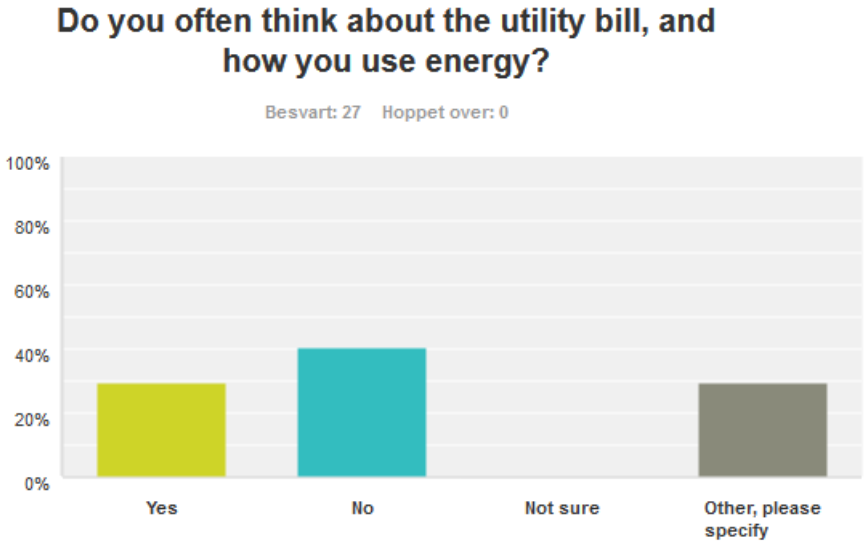

Figure 17 Survey - Often think about utility bill and usage of energy

One noticeable trend in these surveys was that persons living at home with their parents had a laidback approach towards everything energy related. When asked if they noticed any difference in the energy usage in the different seasons of the year one answer was “My dad pays the bill” and another one answered, “I do not pay the bill, nevertheless I do not use that much electricity”. When asked if they think about how they use energy the respondents that lives at home only think about it when they are told to do so.

Figure 18 below shows that most of the respondents of the survey was not sure if they wanted to utilize a form of energy management / information system with personalized user profile and analytical functions.

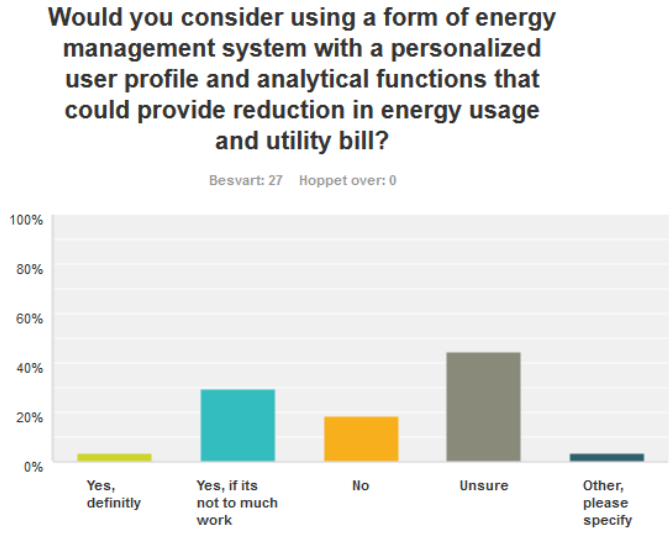

Figure 18 Survey - Would you use a form of energy management system

7 DISCUSSION

7.1 HOW CAN BUSINESS INTELLIGENCE BE USED FOR MAKING THE USERS MORE AWARE OVER THEIR DAILY ENERGY MANAGEMENT?

To answer this question, I carried out different sort of research and based on the results I proposed different types of business intelligence tools, that can be found in table 1. These tools were chosen based on what the respondents wanted from a smart house information system. However, there are pros and cons for implementing business intelligence and analytics in a smart house system. As mentioned in section 2.6 business intelligence is mainly for a complex business environment, with the introduction of smart meters and other elements and functions the volume of data from "only" residential houses will increase, and as (Turban et al., 2011) stated in his book there is a need for not only having the information system to analyse the data but one must make sure that the consumer understands the data. Feedback and visualisation does not help if the users don't understand and with the huge amount of data being generated the importance lies in the analysis of the right information and provide the user with the right information as stated by (Ranjan, 2009).

Different households require different types of information, just like the different business in the world, however the basic information is the same for the households. By utilizing BI tools and providing the right input for each individual household BI can eliminate much guesswork and with that the user can quickly respond to changes relevant for their needs. The key in utilizing BI for making the users more aware over their daily energy management is to have the users identifying what is important to them and how they use energy, this can be done by using the proposed method in section 5.1.2, and use that information as what to analyse with the business intelligence tools.

The main way of utilizing BI as I see it, is to incorporate its functionality into the decision-making element of the information system, there the BI tools can provide the right information at the right time based on information from the user. However, this way of doing it is time-consuming and one can end up with information from the users that are not applicable as input in a BI tool. Another aspect of business intelligence is the issue with it being primarily about generating standard reports and/or answering queries (Davenport, 2010) and the fact that businesses have problems with using BI in an efficient way. There is an amount of work required with implementation of business intelligence, identifying input, what is the right information and how to keep up change with the changes in the household.

(Pierce et al., 2010) stated in their article that the everyday domestic environments are not designed to promote and sustain energy conserving interactions. To overcome this the authors proposed that the environments must be redesigned with the use of human-computer interaction and interaction design. As of yet this has not happened and therefor there is a need for users to have another approach to energy saving and energy management. My findings regarding energy related activities were that the activities often only were acknowledged when the utility bill arrived the household. When the utility bill was read the findings showed that users often had one of two approaches; discussed it with others or got irritated and did nothing. The utility bill is the results of that the environments are not deigned to encourage energy saving. The findings also showed that most of the respondents recognizes four main tasks and goals in and information system were nothing revolutionary as shown in the use cases in section 4.5.1, this however makes it more easy to identify what business intelligence tools could use as input and what to analyse.

7.2 How can energy management be used to persuade the users towards behaviour change?

Based on my findings, not many were acquainting with the term and therefor were not able to provide my research with much results. A reason for this can be because energy management is not a term much used in the Norwegian vocabulary and not in the residential sector. However, after explaining the term in brief most of the respondents. This is interesting because the way most of us uses energy in our daily life is "energy management", this just shows that the term has not reached the residential sector as of today. The findings from the interviews showed that the females wanted something to use as an aid to help them to teach the children about energy usage and saving, this shows that the proposed energy management planning method could be useful from a learning point of view.

My findings also indicate that energy management in combination with a decision support tool was also something the respondents were interested in, however as with plain energy management method; only if it was not difficult or time consuming. My findings also showed that feedback of some sort would be required in addition to the proposed method, according to (Abrahamse et al., 2005) continuous feedback is the intervention that seems to be most successful for reducing energy. The authors also mention that many studies have concluded that continuous feedback has proven most effective but in reality other intervention strategies has been used as well. By combining the proposed method and feedback according to my findings the aim of behaviour change will occur.

From a user's point of view, the energy usage is often controlled by habits and unconscious usage (Abrahamse & Steg, 2009; Pierce et al., 2010). The consumption is often controlled by split-second decisions and that was something I found in my research, in the long run it is these habits on split-second decisions that must change.

The proposed energy management planning method is based upon (Norman, 2013) seven stage of action cycle, this cycle makes it easier for understanding the users and their action. As (Norman, 2013) also pointed out, most activities humans do every day are opportunistic and does not engage in planning and analysis the activities are done as the opportunity arise. this is one of the aspect this thesis aimed to address when it comes to energy management and try to make use of the mental models and the seven stages of action cycle.

My findings suggested that smart house and energy management were somewhat familiar to the participants but nothing more. The survey showed the findings from the interviews and workshop regarding, the utility bills, using an energy management method and motivation were applicable to society's opinions. However, this survey did not receive as much answers is I hoped for, there are not enough data to make a generalized conclusion, this is something I could have done differently, by distributing the survey in other channels and promoting it more.

The findings from the interviews show a relationship with the literature in section 2; In their article (Abrahamse & Steg, 2009) discuss how changes in energy use may depend on socio-demographic variables as well as psychological variables. They found that household's energy saving (changes in behaviour) appeared to be mostly associated with psychological factors, whereas energy consumption is mostly determined by socio-demographic variables. When it comes to feedback and visualization different forms of intervention are discussed by (Abrahamse et al., 2005) in their article, and their findings correlates with the results from the interviews. The first step in designing and implementing interventions aimed at reducing energy use is through a problem diagnosis, by identifying behaviours and examine motivational factors which can led to change.

As the interviews showed, the main motivation was money, however to keep the motivation up there is need for more personal motivation or a goal-oriented approach as discussed by (Zhou & Yang, 2016). When feedback, visualization and behaviour change was discussed, the general opinion amongst the respondents was that they thought it would be used in the beginning and after a while they would forget it. This is based on habits, and changing habits is not an easy job because it requires work. This is discussed by (Pierce et al., 2010),in their article where they mentioned the fact that it is difficult to understand peoples routines and habits as discussed in section 2.4.

The workshop provided my research with different findings. When it comes to decision-making the activities and the findings showed that personal preferences, comfort levels and context plays an important role, and this is something that will vary depending on the season of year, how the person feels that day amongst other. This just shows that one general approach will not suite all and that makes it harder to get "every" household to use an energy saving system. Behaviour changes was also identified as hard and something that requires an amount of work and motivation. Motivation on the other hand was also identified as difficult because motivation varies depending on where the person. The findings from the research also showed that the participants had different workflows and that the approach towards saving changed depending on emotions, season of the year etc., this again is closely linked to the decision making process. As mentioned by (Bitterman & Shach-Pinsly, 2015; Wilson et al., 2015) there is a need for more social science in the field of energy, social-science researchers have a greater understanding of how humans can be motivated and as discussed by (Norman, 2013) in his book, humans use mental models and these models can sometimes be inherited by others meaning that the approach towards energy the mother has can be inherited by the children. Findings from my research shows that females with children recognized the need for teaching children the importance of energy, if the mother has a mental model that does not relate with energy saving the children would inherit this approach. As discussed by (Norman, 2013) these models are created by the human interaction with devices, and as mentioned by (Pierce et al., 2010) the everyday domestic environments are not designed to promote and sustain energy conserving interactions.

7.3 IN WHAT WAY CAN THE SMART (IN) HOUSE CONCEPT IN COMBINATION WITH BUSINESS INTELLIGENCE CONTRIBUTE TO ENERGY MANAGEMENT ON A HIGHER LEVEL AMONG THE CONSUMERS?

According to the literature review performed in chapter 2, it is clear that the consumer gains more and more control in the energy market. With the consumers gaining more control, they will also decide for themselves whether they want to save energy in a certain way. According to (Balta-Ozkan et al., 2013) that the smart house in itself is a young industry and it does not know what the consumers want. This puts the consumers in the "front seat" and they could potentially customize the smart house industry. One potential way of doing this is that the consumers think about themselves as the chief executive officer (CEO) of the home, and a CEO needs to know; what happened yesterday, what happens today and what can happen tomorrow. To do this feedback is required, and almost all of the literature in this thesis and the previous literature review discusses the element of feedback and how important it is and how feedback can provide information about almost everything. This is something I considered as a problem, the users might get feedback about information and data they are not interested in, and that could potentially lead to users discarding the feedback device. My research on this area showed that feedback is something that has come to stay however the users themselves want to be able to define much of the feedback based on their current situation.

To do this, the users need to take a more active approach towards their energy management, and according to my research few or none knew what energy management could be used for and the benefits.

By implementing business intelligence in the smart house concept it can provide the user with more personalised feedback. This was something the respondents recognized as something they wanted to have as well as being able to define their own goals and motivational factors, this is a form of behaviour-oriented paradigm acknowledged by (Zhou & Yang, 2016).

If the users in the smart house environment will be able to gain more confidence and the adoption of smart house concept increase, the designers and developers need to have some guidelines. These guidelines correlated with the proposed method, and as such aims for increase in understanding and confidence. The guidelines ensure that the designers obtain a better understanding of the users and the method aims at providing more user confidence and change in behaviour towards energy.

Based on the findings from the literature regarding the smart house research does not consider the user enough and therefor the smart house has limited appeal, it is only the highly motivated users that will consider a smart house (Balta-Ozkan et al., 2013; Wilson et al., 2015). Based on the latter and the findings from the research I developed a set of guidelines, these guidelines in combination with the developed method aims at making the developers acknowledge the users more and the smart house adoption will hopefully increase. However, from the survey, one of the results showed that (figure 18, would you consider) not many was sure about utilizing an energy management system because they were afraid it was too difficult, these results were different from the interviews where the most of the respondents answered that they would use such a system or method if it was not too difficult or time consuming. This shows how difficult the adoption of the smart house concept is, the respondents in the interview could have been persons with a more positive attitude towards smart house concepts and technology and the respondents from the survey could have been persons with little interest in the latter. As the article from (Balta-Ozkan et al., 2013) shows on this subject, the social barriers of adopting the smart house are many and complex. A flaw in both the survey and the interviews on this subject were that the topic of social barriers was not investigate more. That could have provided my research with more information regarding how the user could overcome those barriers and gaining more confidence in the concept.

Based on my findings with regards to use business intelligence and energy management, a method was developed. This method aims at utilizing the users mental model and addresses the element of the domestic environment is not being suitable for energy saving. The method provides the users with tools for planning and awareness. By utilizing the method in the smart house environment the users hopefully will gain more knowledge about their energy habits. This again will empower the user and making them feel more confident about using the smart house information system because they have a deeper understanding about their own motivation, habits and usage. It is important to empower the users, because it was mentioned by (Hargreaves et al., 2010) that visualization in most cases empowers or disempowers the inhabitants of the house.

One problem with the proposed solutions is that the collection of data was smaller than expected, the survey for example received only 27 answers and therefore the results cannot be used for generalizing the finding from the interviews and workshop. However, some of the results correlates with the literature review; motivational factors, the adoption of smart house technology and the “driving in the dark” approach regarding the utility bills. The literature collecting on the other hand was the other way around, the searches provided numerous articles.

This was somewhat problematic because most of the articles did not have focus on the users and it proved difficult to use the literature to support my findings. Behaviour change as a field is difficult to go in-depth to in a short period and even more difficult to use in developing a theoretical method.

In regards to the research methods, in retrospect a more practical method such as a proof of concept or prototype would be beneficial. By actually testing the guidelines and method in the real world it would be easier to determine flaws and weaknesses as well as determining what actually works. As of today the conclusion will be based on theory. Because the underlying data is somewhat small there is a risk that the method and/or guidelines contains flaws and weaknesses I am not able to identify at this stage.

7.3.1 How can such an initiative encourage behaviour change among the consumers?

The proposed guidelines aim at making the developers of smart house solutions more aware over their users, by acknowledging who the users are, what they want and how they want it. The method on the other hand aims at empowering the users and increasing their knowledge and by doing that making them more comfortable in a potential smart home and in the long term changing their behaviour. This method also apt for changing the users' mental models as mentioned earlier.

8 CONCLUSION AND FUTURE WORK

In this thesis I presented a set of guidelines and a method that will make the users more confident in the smart house environment and change their approach towards energy usage.

Intelligent energy consumption services are in an early age, with the expansion of smart grids and smart houses still evolving and developing. Interactive technology with the purpose of meeting personal and differential demands of usage needs to be varied and numerous. The smart house technology as of today does not meet those requirements in a good way. As the research shows, the smart house technology is still in an early stage and does not actually know what the consumers want. The potential users are also reluctant to adopt the latter technology because it is in an early stage of development, and the consumers does not actually know what the technology can offer. This is where this thesis comes into play, by offering the potential users to take an active role in their smart house. This is done by addressing business technology tools that can provide the potential users more control, however energy management planning is also presented as a method for the consumers to change their behaviour and with the aim of using smart house technology in the end.

This thesis demonstrates that there is a need for acknowledging the users more in the smart house research. It also demonstrates that there is a need for involving elements from social science and multidisciplinary research if the users shall obtain a permanent behaviour change.

8.1 FUTURE WORK

There are several elements which would benefit from further research. First and foremost, a practical method to test the proposed guidelines and method over a period to identify if there are some behaviour change potential. A test period would also demonstrate if the latter and business intelligence actually is something to consider in a smart house concept. Testing the method in a real smart house or regular residential house would also prove beneficial to see if the latter is something the users actually wants to use.

The research would also benefit from a larger amount of respondents to obtain more data that could be used for improving the proposed method and guidelines.

There could also be beneficial to include more psychology in order to ensure that there is a higher chance of successful behaviour change.

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10 LISTINGS