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Energy Management Service Design:
An exploratory case study for Portuguese household

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Master Thesis

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This Master Thesis dedicated to April's martyrs!

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Abstract

Electricity is an important component of our life. However, people are not completely aware of how they use it and especially how to use it more efficiently. Nowadays, consumers are becoming increasingly concerned about their energy bills and high price of consumption but due to the lack of information and appropriate knowledge they are rarely engaged in more efficient behaviours.

This means that people are in need of support to an efficient energy usage, to leverage flexible tariffs and renewable energy sources in producing added value. Although, there is a wide range of smart appliances and management systems, still households need innovative services to provide them more benefits and autonomy over their home energy controlling.

Therefore, the proposed study intends to explore strategies related to the development of energy services and develop ideas (in the context of Portuguese households) concerning experience & behaviour of end users in energy management issues. Based on this proposal, new concepts and design solutions were developed for an improved service. The goal of these new service is the support for an active participation of end users in energy management using a Home Energy Management System and to help in establishing alternative and more efficient energy usage patterns.

The present study made use of a qualitative approach and revision of existing researches. A study of users' experiences was undertaken to understand their requirements. Focus Groups and Individual Interviews were conducted. Data collection was performed using the Customer Experience Modelling (Teixeira, J. et. al. 2012) to systemize users' experiences and transfer them to an ideation phase. Multilevel Service Design (Patricio, L. et. al. 2011) was used to draw a new service based on gathered data. Then, prototypes were built to make a new service concept visible and tested with potential users getting their feedback.

The main contributions of this study are insights about user's experience & behaviour in energy management and therefore its application to a new service design process for energy management service in a Portuguese context.

Keywords: Energy Management Service, Demand Response, service requisite, Service Design, service artifacts

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List of abbreviations

B2B - Business to business

B2C - Business to customer

BEAD - Building Energy Analysis Device

CEM - Customer Experience Modelling

CER - Customer Experience Requirement

CSI - Customer Satisfaction Index

CVC - Customer Value Constellation

DR - Demand Response

EMS - Energy Management System

ERSE - Energy Services Regulatory Agency

GUI - Graphical User Interface

HEMS – Home Energy Management System

ICT - Information and communication technology

IDC - International Data Corporation

IOT - Internet of Things

IT - Information Technology

MSD - Multilevel Service Design

RTM - Real Time Price

SB - Service Blueprint

SD - Service Design

SEB - Service Experience Blueprint

SXP - Service Experience Prototype

UXP - User Experience Prototype

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1 Introduction

Energy sector is becoming a more crucial field in our daily life and it is integrated with other different areas. It is impossible to imagine our life without electricity. Nowadays, the sector also requires innovations in order to be used efficiently. On the other hand, a financial factor plays an important role in this concept as well. The financial benefit of this service not only belong to customers but also to the energy companies. The profitability from customers perspective is their availability to use energy mainly in cheaper hours according to real time price program, whereas for the companies is to gain cost cut in logistic by getting load reduction in the peak hours.

Beside the financial issues, environment factor is one of the main points that customer may concerns. Regarding to this notion, the global warming should be noted which is a primary problem of too much carbon dioxide in the atmosphere. This carbon overload is caused mainly when we burn fossil fuels like coal, oil and gas or cut down and burn forests to generate energy. And it steadily drives up the planet's temperature, creates significant and hazardous impacts on our health, our environment and our climate (European Commission, 2017).

Moreover, another purpose of this service is to empower end users' dominance over their energy consumption. Therefore, from those factors arises the need of producing well-designed HEMS.

As a direct energy consumer, the end user is an important figure in this issue. Inevitably, the energy sector will deepen the collaboration with the customer in order to increase energy usage efficiency. As such, the customer's involvement in Energy Management services and the study of value co-creation in this sector is an important topic that requires deeper research.

1.1 Background of Energy Management System (EMS)

> *"Energy efficiency should be on the priority list for all home improvement work these days. Canny builders will be able to provide homeowners with energy efficient measures which help them to save money and the planet."*
>
> *Sarah Been (English Property Developer)*

The exhaustible trait of some energy resources and their vital impact to our planet make us to think how we can use it effectively and optimize our resources. Nowadays, most environmental problems such as climate change, global warming etc., arise from irrational usage of energy (National Geographic, 2017). This allowed the introduction of the Energy Management System (EMS) concept. This notion emerged in the last decade and it is frequently referred to as new service concept in the energy market. Early EMS operations were based on analogue meters with limited functionality, but with agile and easy to understand data outputs (see Figure 1).

***Figure 1**: Analogue meters*

However, they were limited in scope and application. Their application evolved rapidly in the early 1970s.

Most of the systems delivered before 1975 were based on Xeros Sigma 5 and Sigma 9. Sigma series were high-speed and general-purpose computers which were introduced by Scientific Data Systems. Those models were able to process in multi-programmed batch, remote batch, conversational time-sharing, real-time, transaction processing modes and controlling concurrent high- speed input/output operations (Scientific Data Systems, 1967).

The technological evolutions in the 80s further changed the EMS, particularly with the advent of personal computers. Early developments of EMS, from manufacturers such as General Electric, Hitachi, Siemens and Toshiba, were based on proprietary hardware and operating systems (Amer, M. et. al. 2014).

The evolution of technology and service concepts, led by the emergence of smartphones and their incremental usage, pushed engineers and designers to collaborate in designing advanced services, for customers, based on mobile applications.

Starting by the market perspective, today's power grid has substantial hourly variations in the wholesale electricity price, and the spikes usually happen during peak hours due to the high generation costs. Nevertheless, consumers are typically charged a flat-rate retail electricity price, which does not reflect the actual wholesale price variations. With the flat-rate pricing, users often consume a large amount of electricity during peak hours, such as the time between late afternoon and bedtime (Qian, L. P. et. al. 2015). Furthermore, the modern EMS is tended to change electric usage by end-use customers from their normal consumption patterns in response to flexibility of price of electricity over time, or to incentive payments designed to induce lower electricity use at times of high market prices or at peak hours (Amer, M. et. al. 2014).

Building stakeholder maps are fundamental steps in understanding the system that will be designed (Mager, B. 2009). In contemporary EMS, there are several stakeholders whose requirements should be fulfilled in a service/product design. These different stakeholders have distinct requirements and influences on the system requirements. Stakeholder's importance is ranked according to whose requirements and interest is priority to fulfil while stakeholder's influence is based on who has positively or negatively impact on the system requirements (Preece, J. et. al. 2002, p. 167). Figure 2 illustrates an aggregate modern EMS stakeholders map, where in the middle the end user is allocated considering its user centric service trait. Then, crossing the rainbow layers, the different stakeholders are depicted as who are main figures and who must be involved to energy management service design process.

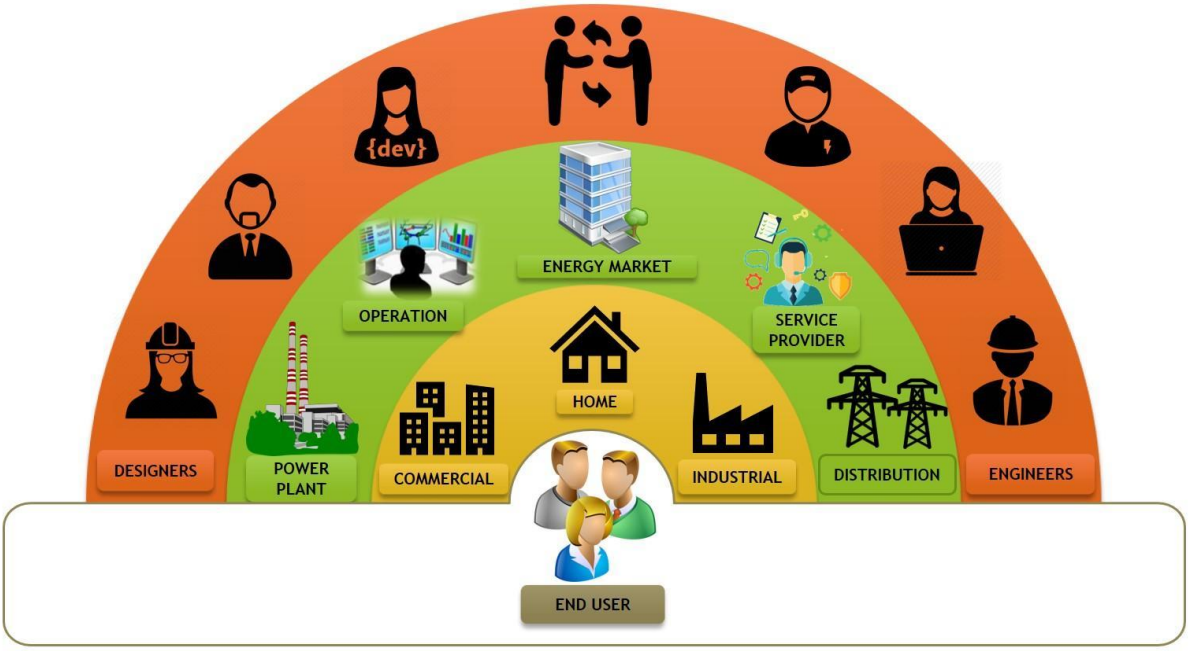


***Figure 2**: Aggregate Energy Management Service Design Stakeholder Map (source: author)*

For the purpose of this research and considering the company's requirement, INESC TEC company which proposed this research topic, the main stakeholder is a domestic energy consumer. The data illustrated in Table 1 supports that our customer segment is reasonable.

As represented in Table 1, the domestic electricity consumers dominate among the electricity consumers, who are roughly five times more than non-domestic users.

Table 1: *Electricity consumers: total and by type of consumption*

	Domestic		Non-domestic	
Territories / Years	**2013**	**2014**	**2013**	**2014**
Porto	129,675	125,961	26,990	30,763
Espinho	14,981	14,527	2,292	2,864
Matosinhos	79,299	76,660	12,154	14,988
Maia	56,743	55,336	9,124	10,920
Póvoa de Varzim	33,926	33,276	5,786	7,210
Santo Tirso	27,341	26,725	3,841	4,836
Total	**341,965**	**332,485**	**60,187**	**40,818**

Data Sources: DGEG/MEc

Source: PORDATA

Furthermore, there are already approximately 11 thousand domestic consumers who produce and sell electricity to the grid. These active consumers, who appeared in just under two years, could "represent a paradigm shift in the configuration of the electrical system". This report is made by the Energy Services Regulatory Agency (ERSE) in their opinion - the proposed investments for the distribution network until 2021 (Suspiro, A. 2017). This statistic indicator makes us to think about a new customer segment - the prosumer - in the future.

1.2 Participation of people in energy management issues

> *"Linking financial element to energy consumption I think has a huge role if you think about a display instrument that could teach us about what we are using, how much it costs us, how much it is saving, and therefore change our decisions."*
>
> *Dan Ariely (Professor of Psychology and Behavioral Economics)*

The energy market is one of the last industries that is transforming itself from analogue into digital. Environmental, political, and technological developments ask for a radical change: the

energy infrastructure has to be transformed into an active network, with intelligent components and advanced communication facilities. This change will give rise to the development of new business concepts and the coming into existence of new services (Timmerman, W. and Huitema, G. 2009).

Electricity grid is composed of several parts like power generation, transmission, distribution and end user demand which are important factors in the energy supplying process. Meanwhile, those factors are adjusted for energy efficiency, whilst the last part of the electricity grid that is presented as the end user is still a passive part of this network (Amer, M. et. al. 2014). This research aims to find out incentives to increase user's active interaction with the system.

In the context of intelligent electricity grids, there is now a large-scale integration of different devices and entities capable of participating in services that go beyond simply supplying electricity. One of these entities is the end customer who typically has at their disposal a set of flexible loads that can take advantage of services associated with Demand/Response (DR).

The benefit of the active participation of consumers in energy management may be greater if it is possible to associate controllable micro-generation beyond the controllable load. This micro-generation can be achieved with solar panels or wind turbine as an example.

Classical demand-side management defines basically as "load shifting" and "peak clipping" load shape objectives which are most widely applicable and most relevant to energy efficiency. Nowadays, the predominant demand-side management activity is DR which involve the customer to this process (Amer, M. et. al. 2014). The customers' needs to be supported to play a role in the energy market. They are one of the actors in a complex value network, as was shown in Figure 1. The end users want to be in control of their own energy. Intelligent energy-management services are needed to support them in their role of consumer. These services need to be designed and developed (Timmerman, W. and Huitema, G. 2009).

Considering all that was previously mentioned, it becomes clear the need to research and understand consumer behaviour towards the development a set of adaptable energy management services that allow maximizing the participation of potential end users and support them to leverage the flexible use of energy.

In the scope of this work, it is expected that new strategies for the development of energy services and for interaction with potential users of energy management platforms will be explored to maximize their participation.

1.3 To ascertain values for an active participation of end users into an EMS

This study aims to contribute to the understanding of the customer behaviour in to perceive his/her real experience requirements in the context of energy consumption and in this way to contribute to an active participation.

Based on customer unmet needs this research will develop a concept contributing to the design of a new service that can be profitable for all stakeholders, mainly for service provider and end

user. More precisely, to support customer in energy saving and their active interaction in the Energy Management System (EMS) in order to help the service provider in terms of Demand Response (DR) issues and to reach lower cost in energy value chain. Thus, beyond of all those goals stays to reveal identification and characterization of the way for the integration of end users in energy services.
Mission statement is a valuable tool to present company's purpose and strategy to stakeholders, while vision portrays company's desired features and guides development stimulation (Tanković, A. Č. 2013). Moreover, the mission statement should present services or products, markets, profitability, objectives and goals (Akeem, A. T. et. al. 2016). Thus, Table 2 summarizes the service plan based on mission and vision of the company related to this service.

***Table 2**: Mission and Vision*

Mission Statement	
SERVICE DESCRIPTION	HEMS will offer cheaper schedule based on users' preferences and real time pricing to use appliances. Moreover, it will allows to control appliances and data.
BENEFIT PROPOSITION	Our value proposition to enhance users' experience and make them to gain more profit and control over their energy consumption.
KEY BUSINESS GOALS	• To increase user's energy consumption experience • To reach 60% of energy consumer in Portugal
PRIMARY MARKET	We identified that our target market will be domestic energy consumers. We believe that this segment is more in need of to get support in term of efficient energy consumption.
SECONDARY MARKET	Our secondary market is other type of energy consumer like non-domestic.
Vision	
Vision is to capture all kind of energy consumer in future including domestic, non-domestic, industrial, agriculture etc. and enhance their experience and to provide more productive service.	

Source: Author

1.4 HEMS Research Questions

Formulating research question is a fundamental step of research process. It illustrates the researcher's goal explicitly (Bryman, A. 2012). This way, it is necessary to engineer the relevant research questions. The research questions cluster the main goal of research into sub goals to get detail insights about the study's object.

1. What type of requisites could promote a more active participation of customer into an Energy Management Service?
2. What can be made to increase efficiently consumer's energy management?

On the way of answering to these two research questions, this work intends to get a deeper understanding of customer behaviour and customer experience concerning home energy usage.

1.5 The Company: INESC TEC

The undertaken research was proposed by INESC TEC company. INESC TEC - the Institute for Systems and Computer Engineering, Technology and Science - is an Associate Laboratory with more than 30 years of experience in R&D and technology transfer. Present in 6 sites in the cities of Porto, Braga and Vila Real, INESC TEC incorporates 13 R&D Centres and one Associate Unit with complementary competences, always looking to the international market.

INESC TEC brings together more than 725 researchers, of which more than 350 have PhDs, forming a robust cluster with complementary skills and with notable international presence. INESC TEC invests in Scientific Research and Technological Development, as well as in Advanced Training and Consulting, Technology Transfer and supports the Establishment of new Technology-based Companies.

INESC TEC Strategic Objectives:

- To develop science and technology that is capable of competing on a national and international level.
- To participate in the technical and scientific training of high-quality human resources to enhance the nation's capacities and encourage modernisation.
- To contribute to the development of the scientific and technological education system, modernising it and helping it to adapt in order to meet the needs of society and the economy.
- To promote and incubate business initiatives in order to improve R&D activities and encourage young researchers to take risks and use their initiative.
- To create a modern Portugal, a well-established economy and a high calibre society by following the objectives that have been outlined.

Centre for Power and Energy Systems (CPES) is one of R&D centre that associated to our study. CPES basically works to support regulation and electricity market, technical and economical management of distribution systems, integration of dispersed renewable energy generation in electric sector.

CPES objectives:

- Consolidate current areas of scientific research and current contracts. Continue to work in the areas of traditional power systems and emerging domains related to DMS/EMS (Distribution Management Systems/Energy Management Systems) and smart grids.

- Develop partnerships with Portuguese companies to intervene in niche markets where INESC TEC holds a reputation of excellence.
- Increase international activity by participating in European Union R&TD projects and obtaining contracts in collaboration with local partners.
- Enhance the training of human resources and increase scientific diversity through MSc and PhD courses, visits to foreign institutions and by attracting guest researchers and students with study grants from foreign institutions in countries such as Macao, Brazil and other Latin American countries.
- Increase exposure of results through participation in international conferences and systematic publications in international journals.

(INESC TEC, 2016)

1.6 Dissertation structure

The following sections of research are: in Chapter 2 existing literature related to the topic will be reviewed under different subtitles. Main gaps will be identified to guide our study.

Going on to Chapter 3, Service Design process will be executed on three main stages (see Figure 3) (Sarmento, T. 2013): 1) Customer experience exploration; 2) Ideation; for generation of ideas modelling and apply some of the ascertained experience requirements 3) Reflection; to present preliminary tests. At the beginning, methodologies and different approaches regarding Service Design will be analysed and relevant methods will be chosen. A qualitative approach will be used and data collection methods will be identified. Based on the gathered data and chosen methodology the Service Design will be started and finalized with a new service concept. As a final stage for reflection, prototypes of the service will be developed and concerted to mock-ups to test them.

In Chapter 4 we are going to depict the discussions and the results of each stage and consequent findings.

It is expected by the end in the Chapter 5 to conclude our study contributing to research objectives and literature in the field of HEMS in the Portuguese context. Furthermore, we will mention some clues for future research guidance.

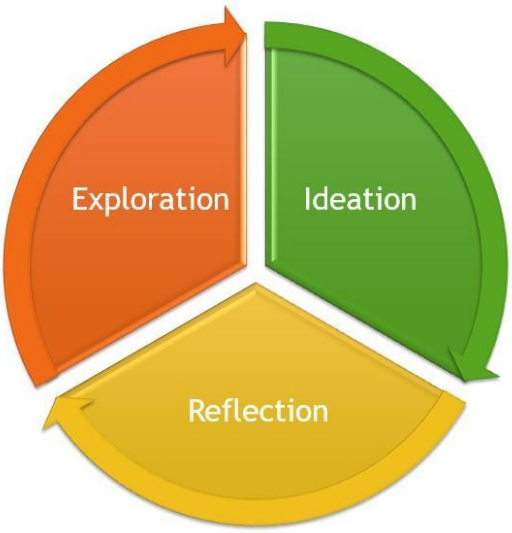


***Figure 3**: Service Design Process (a)*

2 Literature Review

Some researches considering end user's role and behaviour in the EMS context were published (Meng, F-L. and Zeng, X-J. 2016). These studies emerge from different research areas either being electronics, service marketing, domestics etc. Going on to literature review stage, in this chapter, existing studies related to this topic will be investigated.

Literature review will be carried out in the several aspects such as Home Energy Management System (HEMS), customer experience, customer behaviour, Service Design (SD), Demand Response (DR), mobile service design and artifacts in HEMS. The HEMS could be considered an effective if it is productive for end-user and for electricity grid as well. Different arguments should be considered to fortify the customer's satisfaction and to address the potential cost reduction in the energy value chain.

2.1 Home Energy Management System (HEMS)

Nowadays, wide range of tools are available for HEMS based on DR mechanisms and incentives for the end-user's involvement. This way, HEMS is an integrated model based on collaborative activities. This may integrate procedures like monitoring, controlling, optimizing and load shifting in peak hours to support usage of electricity energy in an efficient way. A HEMS is a complex system with several components.

According to Liu, Y. et. al (2016), technically HEMS's main factors are five: The Smart meters, the Sensing devices, Internet Communication technologies, Smart appliances and finally the HEMS itself that covers all these components.

The first one is the Smart meter device that serves to measure consumption, collects data and sends it to the system to be analysed. Through those smart meters, relevant data about users' energy consumption is produced. For instance, one of these smart meters is produced by Siemens technology company, generating data for both end user and service provider (see Figure 4). Siemens is implementing a complete system made up of smart meters, secure transmission technology and IT systems for collecting and processing the measured data in Austria (Ross, K. 2016).

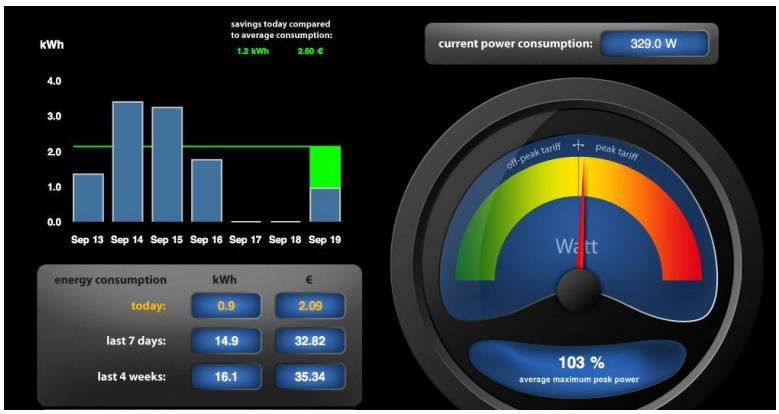


***Figure 4**: SIEMENS smart meter interface*

The second one is the Sensing device that allows the HEMS to get measurements of current, voltage, temperature, motion, light, occupancy to process and analyse. Based on this information the best schedule is selected by the system for the different home appliances.

Going on to the next component that is enabling ICT, it is difficult to conceive any smart system without it these days. In HEMS, ICT supports both wireless or wired communication between different appliances and systems.

The fourth main factor is smart appliances. In order to fit HEMS and communicate, monitor and control easily it is important to use smart appliances. However, nowadays there is a wide range of devices like smart plugs that can allow old devices to be controlled almost as smart devices.

The final mentioned component is the energy management system that combines all factors listed above in itself. This is an integrated system based on energy management principles, software and hardware.

All mentioned factors above are critical. However, there is lack of consideration of a superior designed service to support an active participation of customers in the HEMS and their co-creation trait in the process.

Colombia has a model of HEMS called GEDE (Vega Escobar, A. M., et. al. 2014). The model involves distributed generation for self-supplying, communication protocols, sensors, and intelligent metering systems. Also, the model allows the interaction between the end user and the electric energy value chain, offering a new role as an active user and being able to manage generation or consumption transactions. The "active user" is central part of the GEDE system, which leads to get cultural awareness on energy efficiency and saving. The advantage of this model is that it is designed based on variables namely political, economic, social, cultural, regulations and environmental that have a fundamental influence the customer behaviour. In this case study, Customer behaviour was explored and observed deeply. This allowed to design the interface in a way, so the end-user can access real time data and have freedom to decide and

to control. Moreover, being a customer centric service, GEDE considers not only consumer but also prosumer in the interaction with the service. Through the GEDE, prosumer will be able to manage his/her self-generated energy and injecting his/her surplus energy to electricity grid to earn a financial benefit.

This Colombian model is the framework merely based on technical and financial incentives. So, there is lack of Service Design principles which are vital aspects to design a customer centred service.

Considering our service context, we would like to mention a mobile application for HEMS that is "EDP re:dy" developed by EDP energy company in Portugal (see Figure 5).

EDP re:dy is an HEMS that gives control and permissions to the customers to access data and control to their appliances. However, it does not offer any financial incentives and does not invites customer to collaborate and cooperate.

All the service features are based on monitoring and controlling. Through this application customers can schedule usage time of appliances manually according to their energy tariff. Customers have access to remote control of their devices and monitor energy consumption. Moreover, at EDP re:dy solution, prosumers can monitor their solar power generation. Nevertheless, it does not predict renewable energy generation considering the weather forecast (EDP 2016).

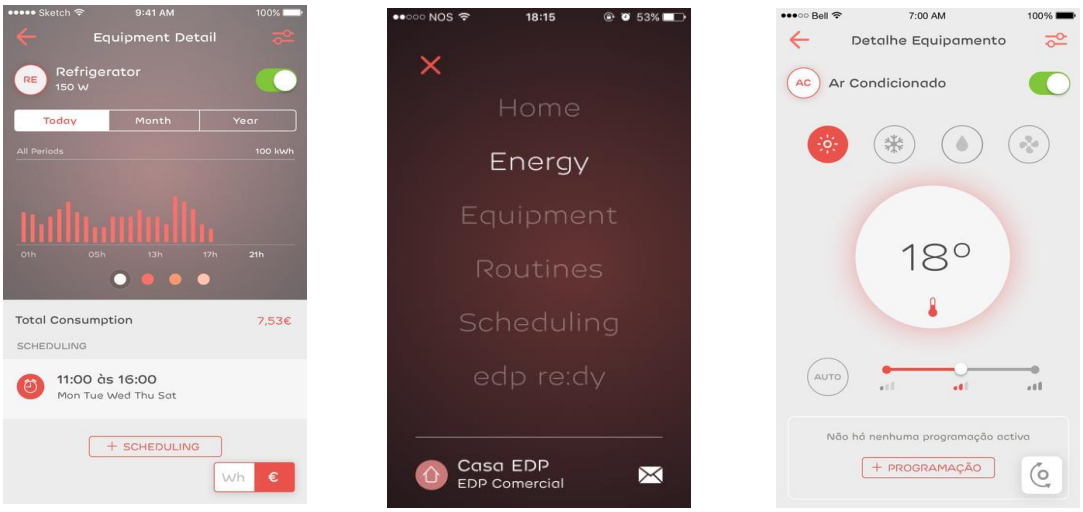


***Figure 5**: "EDP re:dy" interface*

The main disadvantage of this application is not having a remarkable impact on the end users' interaction, so they cannot reach to leverage flexible tariffs or interact to DR issues.

A Building Energy Analysis Device (BEAD) was developed by a Turkish team under "Climate LaunchPad" Project in 2016 (see Figure 6). BEAD is an Internet of Things (IoT) device that analyses and learns the daily use cycle, user behaviour and occupancy changes of commercial

buildings to give feedback to automation systems connecting it to the real-time operation of the building. BEAD analysis learns from the building and its users and is empowered to start taking over the most intelligent operation of the building. It controls automation and redirects energy to be used where and when it is needed. Furthermore, BEAD analyses how commercial buildings consume energy according to human behaviour, occupancy ratios and environmental changes in the building to give real-time feedback to the automation system (Engerati, 2015). Figure 6 portrays BEAD's interface and connection.

***Figure 6**: BEAD's interface and connection*

The BEAD is very useful devices in term of designing HEMS. Because BEAD analyses human behaviour which is key factor in this service.

2.2 Customer experience

> *"Customer experience construct is holistic in nature and involves the customer's cognitive, affective, emotional, social and physical responses to the retailer. Moreover, the customer experience encompasses the total experience, including the search, purchase, consumption, and after-sale phases of the experience, and may involve multiple retail channels."*
>
> *Peter C. Verhoef et. al.*

It is true that customer experience is formed based on people's feelings about a service or a product. C. Shaw et. al., (2005) claim that customer experience is strongly related to customer emotions. There are a lot of messages that the brain takes about Customer Experience. We also can associate it to our senses like what is our reaction or feeling when we see any images, colour or hear sound. It means when customers interact with service or product, they always picking up signals, which influence on their experience (C. Shaw 2007). Hence, all factors listed above

have effect on customer experience and shape it.

We can notice relevant changes in customer engagement over last decade. Customers are more demanding, because today they have grown accustomed to the methods of engagement; Today, customers enjoy having good experiences in all sectors from banking to telecommunications, insurance or retail. In the same way Energy retailers need to review everything about the way they understand, connect, transact and engage with customers. They need to fully embrace digital channels like social media and mobile (IBM Sales and Distribution, 2016).

> *"Our vision is that customers will be able to interact with us the way that they want to interact with us."*
>
> *Gregory Knight (Chief Customer Officer and Senior VP, CenterPoint Energy)*

Approaching by this aspect, there is need to investigate and develop a new channel that customer is willing to be involved in this way.

In terms of the interaction way, it is more challenging to achieve customer satisfaction. The existing systems used by utilities, like EDP re:dy, confine customer interactions. Energy service providers hereby must not only to deliver safe, reliable, affordable and sustainable energy, but also to meet the needs of demanding customers and enhance their experience. According to IBM this can be achieved by the points listed below:

- *Move to more of a self-service economy. Customers need to be able to interact with their utility using whatever channel they prefer, whether it's using a mobile device, chat, website, or a live call center agent. Each channel should provide the same level of service and enable a customer to easily move from one channel to another seamlessly.*

- *Meet or exceed customer expectations. Customers want consistency, quick answers and seamless interactions regardless of the channel, they use. They have countless examples of systems like interactive voice response, web and mobile options from other industries, such as banking and retail.*

- *Offer renewable options. In some markets, customers may be able to sell surplus energy back to the grid operator. Reductions in prices and improvements in battery technology and availability have increased the viability of more renewable energy options. As customer-owned generation, such as solar, continues to become more affordable and effective, more customers will demand it.*

(IBM Sales and Distribution, 2016)

Another challenge arises from concerns about how to make a customer to adopt a new way of interaction or service providing. According to IBM Sales and Distribution, (2016), satisfying customer demands for a sophisticated and instant interaction via mobile applications requires advanced capabilities and technologies. Hence, the energy retailers' efforts need to be focused on a profound investigation of customer relationships as well as energizing and personalizing the experience.

Another factor which is part of the customer experience concept is the important notion of value co-creation in a service. Co-creation is a process of collaborative, coincident and mutual value creation materially and symbolically. Galvano, M. et. al. (2014) even refers that to involve customers in this value creation process may be seems as a form of exploitation if the "working consumers" are not adequately reimbursed. In the service ecosystem, this value co-creation concept embraces a wide scope which includes all actors' interaction and their role and value created for each other (Beirão, G. et. al. 2016).

2.3 Customer behaviour

> *"Consumer behaviour is the study of the processes involved when individuals or groups select, purchase, use or dispose of products, services, ideas or experiences to satisfy needs and desires"*
>
> *(Solomon, Bamossy et al. 2006, p27)*

Service design in a human-centred service often has to understand or influence the behaviour of people (Mager, B. 2009). Customer behaviour is a paramount aspect as consequence of the customer improved service experiences. It is expected that when a customer feels good service experiences these will influence and contribute to an enhanced behaviour; Considering the role of user at the energy market, these issues have even more meaning.

This way, customer behaviour demands a deep research to understand customer requirements and therefore contribute to the SD with a holistic perspective. The profitability in an energy retailer point of view is trying to learn from customer energy behaviour, analyse them and determine a flexible price and finally attain load reduction in peak hours. Consequently, it reduces the cost in energy logistics (Meng, F-L. and Zeng, X-J. 2016).

The relevant approach suggested by Meng, F-L. and Zeng, X-J. (2016), is dedicated to exploring customer behaviour about energy consumption patterns. The model they suggest is to learn users' energy use based on categorise their appliances into - *shiftable* and curtailable appliances. As a result, the reported data such as the hourly price and the hourly energy consumption of each *shiftable* and curtailable appliance at each hour are available. With all the historical data available, it makes possible to learn from customers' behaviour patterns in using *shiftable* appliances and curtailable appliances.

2.4 Demand Response (DR) Concept

The definition that given by Amer, M. et. al. (2014), the term demand-side load management refers loosely to the "adjustment of demand to match supply", and can be understood as a client's response to demand-side management, represented primarily by DR programs.

According to Federal Energy Regulatory Commission, the DR was depicted that:

> *"Changes in electric usage by end-use customers from their normal consumption patterns in response to changes in the price of electricity over time, or to incentive payments designed to induce lower electricity use at times of high wholesale market prices or when system reliability is jeopardized."*

Similar interpretation about DR by Abrishambaf, O. et. al. (2016), DR is classified into the two main parts: price-based and incentive-based. In this paper, it is illustrated in real time, the active participation of a typical customer in the electricity markets by employing the incentive based DR programs. The program operator of an incentive-based DR program offers its clients fixed or variable financial incentives, in addition to the fixed/Time-Of-Use (TOU) pricing scheme. The proposed program is divided into:

- *Direct load control: Allowing the DR operator to remotely control the clients' equipment.*
- *Interruptible/curtailable service: Integrating the curtailment options into the retail contracts with the clients. The customer receives the incentives as rate discounts or bill credits. They might be penalized in some circumstances, especially if they fail to reduce the consumption during contingencies.*
- *Demand bidding/buyback programs: Offering DR bids by large customers to curtail demand based on wholesale electricity market prices.*
- *Emergency DR programs: Offering incentives to clients to reduce consumption during reserve shortfalls.*
- *Capacity market programs: Offering load curtailment by the demand-side as system capacity to replace conventional generation or delivery resources.*

Pros of this program is it involves not only consumer but also prosumer who has renewable energy source. Moreover, the price based incentives motivate customer to respond vary price and get financial benefit. However, there is disadvantage side is considering financial benefit result is roughly 0.07 Euro daily it does not make sense comparing all provisions like installation of hardware and software to implement this program. In addition, the penalizing issue also could be created a negative customer experience.

The paper by Braithwait, D. et. al. (2002) illustrates demand response program as a general mechanism for wholesale and retail power market to help load reduction in peak hours and develop competition in market. They have clustered demand response activities into three major group: dynamic pricing, interruptible and voluntary load reductions, and customer provision of ancillary services.

One of the mentioned program is dynamic price which ensures real time price (RTM) program

to B2B and B2C market. Through this program customers reflect day-ahead or hour-ahead costs. While in other category customer could get financial incentives if he reduces energy consumption in peak hours. This reduction can be voluntary and mandatory, it depends on contract with the energy provider. Rest of paper depicts demand response program detail to support power market and increase competition in market however, these programs do not provide any incentives to support active participation of customer and make them a new figure in market.

2.5 Interaction Design in HEMS

As introduced in the first chapter, energy management systems evolved from the early days of the analogic meter to the most advanced like Siemens. Although people are much more familiar with digital interfaces and devices, it is necessary to investigate the type of artifacts that via the user will interact with the service (Banga, C. & Weinhold, J. 2014).

It is an essential issue to choose the most relevant design for the defined customer segment. In this term, according to Potnis, D. D. et. al. (2016) mobile apps are a good proposition, despite diversity of operating systems, functionalities, capturing some memory in the device. Moreover, Legner, C. (2014) alerts as well to these computer environment's parameters that demand a proper attention. According to Banga, C. at. el (2014), those mobile operating systems like iOS, Android, are prevalent, so it is difficult to get away from them.

To gather appropriate user requirements and analyse them properly are important steps to be considered. The context and purpose of customers, the *why* of use mobile devices, the task that they are likely (and unlikely) to perform on a mobile device are key factors for customer centred mobile applications (Potnis, D. D. et. al. 2016).

In the beginning of 2014, mobile phones overtook personal computers as the type of devices most commonly used for web access. Those characteristics should be considered when designing mobile applications to increase customer's accessibility. Nowadays, people are using mobile devices and social media than ever before. Consumer technology adoption is rocketing as well. According to IDC, by 2018, the number of mobile users will grow by 50 percent (Banga, C. at. el. 2014).

2.6 Service Design (SD)

According to Mager, B. (2009), a holistic view, interdisciplinarity, co-creative work, visual thinking and a radical approach are necessary principles of Service Design (SD). SD is a holistic process because it is undertaken in different design stages by various perspectives. SD is an integrated process that incorporates different fields, namely management, marketing, technology. For instance, management oriented SD is focused to create value proposition and customer to be able to co-create value through service, while in technology perspective it describes backstage and frontstage technologies in detail (Teixeira, J. G. et. al. 2016). Similar definition by Raymond P Fisk et. al. (2003), service offerings are enabled by complex service

system namely configurations of people, processes, technologies, physical evidence and other resources that create value proposition for customer.

Innovation in services can be related to different dimensions such as service concept, user interface, the delivery system and technological issues (Jeroen P.J. de Jong 2003). Furthermore, "from a service logic perspective, innovative services are not defined in terms of their new features, but in terms of how they change customer thinking, participation and capabilities to create and realize value" (Patrício, L. and Raymond P. Fisk 2013). In this term, sometimes, service innovation offers new ways of interaction and value co-creation with the customer. Regarding to value added, Maglio, P. P. et. al. (2006) claim that the service systems are value-creation networks composed of people, technology and organizations. They also add that modelling the people and their roles as knowledge workers in the system is necessary factor as well as technology. Because, they are a co-creator of value.

As a considerable figure in service design process, the service designers have a great impact on emerging of new services. They are responsible to acquire user's requirements and convert them into potential future service (Mager, B. 2008). On the other hand, the most services are co-produced. It means the design also involves the customer as an active participant to service delivery process. Service should support customers in value co-creation to tailor the service according to their context (Mager, B. 2009).

In terms of this, one of the methods to design new service is the Multilevel Service Design (MSD), which captures different service levels, namely designing service concept, service system and service encounter (Patricio, L. et. al. 2011). MSD provides deep insights about each of those levels studying customer experience, systemize it and based on this to develop new service concepts. Moreover, Customer Experience Modelling (CEM) is a supportive tool in customer experience studying (Teixeira, J. et. al. 2012). CEM depicts the experiences from the customer point of view and offering holistic view encompasses all elements which are involved to customer experience, namely customer experience requirements, artifacts, people and activities. The actors themselves can be the customers or the active figures that interact with the customer. Customer Experience Requirement (CER) is the demand by customer which arise the need of service. The activities are the actions that implemented by customer for any purpose while artifacts are used within the execution of this activities to help customers to reach their goals. As introduced before, to design HEMS requests different overlapped stages which are matches to MSD tool.

2.6.1 Mobile Service Design

> *"…. better mobile service design will reduce the gap between customer expectations and management's perceptions of those expectations, which will have an impact on the customer's evaluation of service performance."*
>
> *Hsin-Lu, et. al., 2012*

The advent of smartphones provokes a new concept in service market. More and more

smartphone applications evolve as a service, and the issue of quality has become one of the most important factors in such services (Dong-Hee Shin, 2014). Shin suggested the Customer Satisfaction Index (CSI) model which is based on the theory that customer satisfaction is created by several factors like value, quality, customer expectation and image of company. Service quality is an essential factor in customers' satisfaction and their loyalty. When service quality is equal or higher than the customer expectation it increases the customer satisfaction. In terms of customer value Shin mentioned that customers assess mobile service according to two criteria: utilitarian and hedonic dimensions. Utilitarian and hedonic are playing important roles in the design and adoption of mobile service.

Service design (SD) in mobile context requires a holistic approach, incorporating customer experience from the beginning to the end. Moreover, designing mobile services implies an understanding and articulation with other channels of service delivery (Sarmento, T. 2013).

Shaping and exploring customers' expectations is vital issue for service providers, because customer satisfaction is expressed by the difference between perception and expectation. If perception surpasses expectation, then the customer will most likely be satisfied (Hsin-Lu, et. al., 2012).

Well-designed mobile service embodies its provider and represents it. Moreover, attractive mobile service increases user interaction with service and enhance their awareness about the service or its benefits. Mobile apps serve as intermediaries between customer and service provider and manage company interaction with current and future customers. In addition, well designed mobile apps could be a source of innovation as it can create opportunity for customers to give new idea or feedback about service or product (Zhao, Z. & Balague, C. 2015).

2.6.2 Mobile Service Interfaces Design

> *"Within Service Design, Service Interfaces are designed for intangible products that are, from the customer's point of view, useful, profitable and desirable, while they are effective, efficient and different for the provider."*
>
> *Mager, B. (2008)*

A user interface includes the methods by which the users interact with a device. Georgiev, T. at. el. (2009) present two main kind of mobile user interfaces:

- Graphical User Interface (GUI) takes user's input information through various mobile computer keyboards and pointing methods which react to the screen. The GUI displays relevant information on the screen of the mobile devices.
- Web-based user interface accepts a user request, transmits it to web server, receives response and displays the information on the mobile device screen using mobile web browser.

The goal of the user interface design is to facilitate the user-application interactivity and to increase the effectiveness of the user's work (Georgiev, T. at. el. 2009).

In this regard, it is very important to find relevant graphical design to provide information to users. Sometimes, systems offer plenty of information especially numerical data and then it could be difficult for users to read, to understand and handle it. Typical way to present numerical data is different dashboards based on graph, pie chart or columns.

Dashboard design is a crucial process in data provision. The challenge is to present numerical data in a simple way and clearly. It is about avoiding confusion, complexity and about the prioritisation of the right information (Lake, C. 2013). There's quite a mixed variety of dashboard examples. In Figure 7, we exemplified the dashboard style which was used by EDP.

***Figure 7**: "EDP re:dy" dashboard*

Considering that data presenting is an important issue in our service delivering, it arises need to pay attention that dashboard design.

2.7 Summary and Research Gaps

The presented literature review contributed to the understanding that there is no an integrated approach to HEMS. That aspect is very important if one wants to design a new service. The lack of this aspect could evoke poor service design without a holistic perspective and consequent customer dissatisfaction.

Considering the customer himself, many dimensions must be researched namely awareness to some kind of technical data, the old equipment such as electromechanical electricity meters need to be replaced by new smart meters and other smart technologies. This may pose a problem for the utilities and the regulators, since early retirement of equipment may not be financially acceptable by end users (Murthy Balijepalli, V. S. K. et. al. 2011).

Additionally, in terms of service interaction, the customer does not interact with technical parts of solution, however, their experience is formed based on value offered by service. More

precisely, besides the technical solution, the customer experience/behaviour and service design principles should be involved in the design process. Thereby, that identified gap will guide the research to design HEMS considering all those factors.

Eventually, considering of the study goal which is to increase the involvement of end user to the service delivering process, this research intends to fill the lack of service co-creation. As a customer centric service, the role of the user is a key factor in co-creation process in HEMS.

3. Methodology

"Not everything that can be counted counts, and not everything that counts can be counted "

Albert Einstein

The research methodology is qualitative comprising data collection on customer experiences and attitudes. Other reasons justify this approach such as the scarce and fuzzy constructs associated to a small Portuguese context. Hence, we need to consider specific behavioural and experiential characteristics as well.

Qualitative research is characterised by its aims, which is related to understanding of some aspects of social life and its methods, which will generate words, rather than numbers, as data for analysis. Qualitative methods generally aim to understand blurred concepts like experiences and attitudes of customer towards any idea that in future it will be real service/product (Bricki, N. 2007).

To Design the service in the HEMS context, this research will consider this qualitative study as an exploratory stage, where we are going to incorporate experiential aspects of the potential users. The following stage, will be a Design stage - where we will apply a participatory approach (Bergold, J. & Thomas, S. 2012) in order to incorporate the potential users' insights into an ideation and reflexion moments.

3.1 Service Design (SD) Tool

"Customer experiences cannot be designed, but services can be designed for the customer experience" (Patrício et al. 2011).

That is why it is important to gain a profound perception about customer experience. A designed service would be successful if it is proposed based on customer experiences, not based on assumptions.

As mentioned in literature review, the relevant SD method for this study was Multilevel Service Design (MSD), which embraces interconnected processes from understanding of customer experience to the service experience blueprint (Patricio, L. et. al. 2011), and it is concluded by the Service Prototyping.

As described in Figure 8, the SD process will be executed in three overlapped sections. Each main section was divided into sub activities. More precisely, on the Exploration part, the customer experience and behaviour will be explored to get preliminary insights. The output of this stage will be trigger for an Ideation phase, where based on the collected data, Customer Experience Model (CEM) (Teixeira, J. et. al. 2012) will be built and ideas will be generated in order to build a service concept.

At the Reflection stage, the Service experience blueprint and the Service experience prototype will be designed based on defined service concept.

Figure 8: Service Design Model (b) (*Source: Author)*

3.2 Exploration

An exploratory study will be carried out departing from the sampling process, the data collection and the data analysis. This segment will be finalized by obtaining insights on the perceptions of potential users about their experiences which will trigger the ideation stage in the next stage.

Before starting data collection and analysis process, we would like to mention Grounded theory which is a usual approach in qualitative research. This method was originated by Glaser & Strauss in their "Discovery of Grounded Theory" study in 1967. In this method, data collection, analysis and eventual theory are interrelated. It is concerned with the development of theory out of the data and it is an iterative approach, meaning that data collection and analysis proceed in tandem, repeatedly referring to each other. (Bryman, A. 2012, p. 567).

This research makes use of Grounded Theory because the essential data is gathered based on customers' experience and attitudes. Moreover, as an iterative process, each time when data change it also changes and shapes our theory based on our findings.

3.2.1 Study population and sampling

Several authors (Bryman 2012, Bricki 2007) defend that in qualitative research the samples should be usually purposive. On the other hand, for grounded theory approaches, the theoretical sampling was mentioned as a purposive sample as well. The idea is to originate theory or refine it based on the collected data. More precisely, it is concerned to evolve theory that emerges within the analysis of the collected data. Thereby, participants are selected to the sample, because they are likely to generate useful data for the project. To ensure that assembly is credible and covers the main groups relevant to the research, one strategy is a maximum variation sample. This involves selecting key demographic variables that are likely to have an impact on participants' view of the topic. Then you can recruit groups that reflect various combinations of variables.

> *"Purposive sampling is a non-probability form of sampling. The goal of purposive sampling is to sample cases/participants in a strategic way, so that those sampled are relevant to the research questions that are being posed."*
>
> *Bryman, A. (2012, p.418)*

For the present study, data was gathered considering the main stakeholders, who are active figures in home energy management service design process. Taking into consideration the goal of the study - end users were selected as a main research population that should be studied. Some criteria are identified for sampling process. Thereby, the research population are all kind of Portuguese family like nuclear, single parent, extended and childless families. It covers the energy consumers, who are responsible for energy bills, with different education level and belong to various age levels. Predominantly sample participants were chosen from Porto district and across.

3.2.2 Sample size and sampling process

An effective way to define sample size could be originated based on theoretical saturation concept. It means that during data collection no new ideas or properties emerge from research units (Charmaz, K., 2006). Therefore, considering time restrictions and research scope, sample size for focus group were 7 participants while 9 participants for individual interviews.

3.2.3 Data collection

Data processing is vital issue because of its influence on the quality of study. The quality and credibility of study starts with the data. The depth and scope of the data makes the difference (Charmaz, K., 2006).

There is a quite mixed variety of methods to collect data depending on the type of research: interview, focus group, questionnaire etc. At the beginning of this stage the "Focus Group" was employed (Bryman, A. 2012, p.503).

> *"The focus group method is a form of group interview in which: there are several participants (in addition to the moderator/facilitator); there is an emphasis in the questioning on a particular fairly tightly defined topic; and the accent is upon interaction within the group and the joint construction of meaning."*
>
> *Bryman, A. (2012, p.502)*

Applying some rules about Focus Group by Bryman, A. (2012) and Eliot & Associates (2005), the event was planned and organized to allow the data gathering process. The event took place in Porto Innovation Hub on 28th April. First session was between 10h and 11h, while second session was between at 11h30 and 12h30. Considering the language restriction, the event was carried out into two parts to collect more details and reliable information about people's experience and behaviour. Former session was for English spoken people, latter session was for Portuguese spoken people. Furthermore, the first part was composed of four (4) people, while second part was composed of three (3) people (see Figure 9).

a) b)

Figure 9: *Focus Group: a) English session; b) Portuguese session*

In addition, language options gave more confident to participants to express their opinions in detail. The event took place in the Porto Innovation Hub - a place that hosts innovative projects for the city research communities. All logistic issues were discussed and coordinated with responsible team by Porto Innovative Hub. Following the guideline by Eliot & Associates (2005), Invitation Card was created to invite participants to the event (see Appendix C). The Invitation Card was designed in two languages with the description about the event and the organizer. Then awareness was promoted through different channels like the Porto Innovative Hub website, social media, face to face etc. this way inviting people based on the theoretical sampling criteria.

Moreover, the consent to participate in the event was prepared with description, under which

conditions participants would be attending.

The pivotal issue in focus group is to design the set of questions that will be addressed to participants. The Advisable amount of questions suggested by Eliot & Associates (2005) - between 8-10 units - were used in our study. Using the questioning strategy by Bryman, A. (2012, p.513), the set of questions were scripted from more general to detailed and it was tried to avoid close questions and asking why.

At the beginning of the event the topic was presented briefly with slides to create initial perception about the event on Home Energy Management System. According to Bryman's (2012, p. 513) suggestion, firstly, "ice break" question was asked to make participants to think out of box:

How do you imagine dealing with your home energy system in the 2030?

This "ice break" question intended to create preliminary perception about the topic. Beside the "ice break" question following Focus Group guideline by Eliot & Associates (2005), questions were clustered into three parts (see Appendix B).

Another important point is to have a transcript with record of interviewees' opinions. In qualitative research, the focus group will be more productive if it is recorded properly (Bryman, A. 2012, p. 504). As such, in this focus group two kits were used to record the conservation namely video camera and voice recorder.
In order to yield reliable and useful information, the individual interview was used also as a data collection method. Therefore, following the guidance by Bryman A. (2012, p. 212), the semi-structured interview was selected for data gathering, and the sample units were interviewed to understand their energy consumption behaviour attitude and preference about HEMS. Predominantly, the individual interview instrument was composed of seventeen questions which were divided into three main sections (see Appendix A).

First part of questions was aimed to learn customer behaviour and their awareness about energy usage, whereas second part was aimed to perceive customer awareness about HEMS and their willing to use it. The purpose of third part was to learn customer preferences about energy service features.

The interview date and place was selected based on interviewee's preference. Beside taking notes, the interviews were recorded by interviewee's consent. As represented in Figure 10, the interviewees were asked about their mobile applications, especially those were used regularly. The conversation carried out around the impact of the application on their behaviours, how they adjust their habits based on data produced by the applications. This was a way to learn how a mobile service could influence on customer's behaviours.

***Figure 10**: Interview*

Table 3 illustrates socio-demographic information of interviewees. Predominantly, study samples were chosen from Porto and its around in both generation total 15 units, which 6 units represented by women, while 9 participants by men. Participants belonged to different ages, likely between 20 and 71+ rates. Regarding to education level, they were mainly in High school level, while only 1 unit was in College degree.

***Table 3:** Interviewees Socio-Demographic Information*

Age	Female	Male	City
20-30	0	2	Porto
31-40	1	2	Espinho, Santo Tirso
41-50	1	1	Porto
51-70	3	4	Porto
71+	1	0	Porto
Total	**6**	**9**	

Education	Female	Male
College	0	1
High school	6	8
NA	0	0

3.2.4 Data analysis

Data analysis is a crucial process in customer exploration stage. Well collected and structured data has great influence on the quality of study. It gives to researcher more deep insights about his/her customer.

Data analysis methods from video or audio transcript should be noted because group interviews were taped and the individual interviews were audio recorded as well. Analysing even a short half hour videotape will take long time for researcher to explore each comment in detail. A common strategy is to look for critical incidents, such as time when users were obviously stuck or marked by comment, silence etc. (Preece, J. et. al. 2002). Following this strategy videotapes and audio records were analysed based on incidents and pattern of behaviour.

Furthermore, Coding is one of the most central tool in grounded theory to analyse data. It entails reviewing transcripts and giving labels to component parts that seems to be of potential theoretical significance (Bryman, A. 2012, p. 568). Strauss and Corbin (1990), mentioned three

types of coding tools on their grounded theory approach namely open, axial and selective coding.

Applying open coding strategy, which is "the interpretive process by which collected data are broken down analytically" (Corbin, J. & Strauss, A. 1990), the data were divided into categories with relevant labels, in order to gain deep insights about sample units' reflections (see Table 2).

In term of analysing the collected data, a few highlighted insights associated to the research topic and interviewees' quotes were chosen in order to understand their distinct points.

Within the interviews, it was mentioned by the participants that they are willing to change their behaviours if they gain financial and environmental benefits. For instance:

> *"I am willing to do possible changes to gain financial benefit and also environmental"*
>
> *Female, 53 years old, Porto*

> "*Give the report in final of the year with all the savings...with something of "you save X animals or plants" OR you reduce the warming in X % "*
>
> *Female, 33 years old, Espinho*

Going on to other attitudes, interviewees remarked several times security concerns especially with technological issues related to the loss of data. This was clearly revealed by a participant (male, 26 years old, Porto):

> *"I am concern that if I lose my phone, what will happen with my HEMS?"*

Another important fact about security issue that we would like to mention is the recent news (see Figure 11). News was about hacker attack to some companies including EDP which is main energy company in Portugal. Although, EDP claimed that:" it was not hit but took preventive measures and ordered to cut internet access" but it is still risky situation for both service provider and users. In this case the users' data could be under the risk. That is why users were more worried about security issues.

***Figure 11**: News about energy management systems security*

In terms of privacy, nowadays it is common issues that people concern about how safe do entities keep their data. This privacy concern was also highlighted a few times by participants.

> *"I don't want my energy date to be used for commercial purpose only by Service provider to analysis and offer cheaper schedule"*
>
> *Male, 26 years old, Porto*

Progressing to the subject of customers' insights. We would like to mention that interviewees were concerned about service features. Several features were remarked but majority of them told about controlling related to appliances and energy consumption.

> *"Remote control and access to my energy consumption data are very important"*
>
> *Male, 55 years old, Porto*

One of the wide discussed issue was interaction artifacts. This issue related to type of technology that is more accessible and easy use in term of service delivery.

> *"Mobile app is good but also web platform because if there is any problem in my phone…"*
>
> *Male, 38 years old, Porto*

3.2.5 Results

The main results from exploratory data gathering were organized into five categories considering the insights from interviews: Behavioural intensions, Security Concerns, Privacy Concerns, Service Features requisites, Technology interfaces.

In the behavioural intension category was organized based on the quotes of the willing of people about changing their actions. Security concerns is related to safety of HEMS. Privacy concerns was organized based on the quotes of peoples' worry about their data. Service Features requisites category was gathered insights about the specific service features that they would like to see in their HEMS. Tec intentions was joined the aspect of the human-computer interaction based on peoples' tendency taste on artifacts.

Table 4 depicts participants' attitudes to the research topic and we labelled these attitudes as different classes in order to understand their different point of view.

***Table 4**: Coding Table of the data*

Category	Insight
Behavioural intentions	*"I am willing to do possible changes in order to gain financial benefit and also environmental" (Female, 53 years old)*
Security Concerns	*"I am concern that if I lose my phone what will happen with my HEMS??" (Male, 26 years old)*
Privacy Concerns	*"I don't want my energy date to be used for commercial purpose only by Service provider to analysis and offer cheaper schedule" (Male, 26 years old)*
Service Features requisites	*"Remote control and access to my energy consumption data are very important" (Male, 55 years old;)*
Technology interfaces	*Mobile app is good but also web platform because if there is any problem in my phone" (Male, 38 years old)*

3.3 Ideation

> *"We can't solve problems by using the same kind of thinking we used when we created them."*
>
> *Albert Einstein*

In Ideation phase, we will strive to generate ideas and build new service concept based on gathered data. The output of previous stage will be used as an input in this part to map Customer Experience Modelling (CEM) (Teixeira, J. et. al. 2012) and Customer Value Constellation (CVC).

Likewise mentioned in the literature review, CEM illustrates the experiences from the customer point of view and by offering holistic view it encompasses all elements which involved to customer experience, namely customer experience requirement, artifacts, people and activities.

As described above, in Figure 12 the CEM was mapped based on the data that was acquired during the interviews to create the holistic view about user's experience, which includes their main requirements, the type of activities that they are willing to do, the actors and technologies that are involved in this process. We designed this map to build bridge between customer experience study and ideation process.

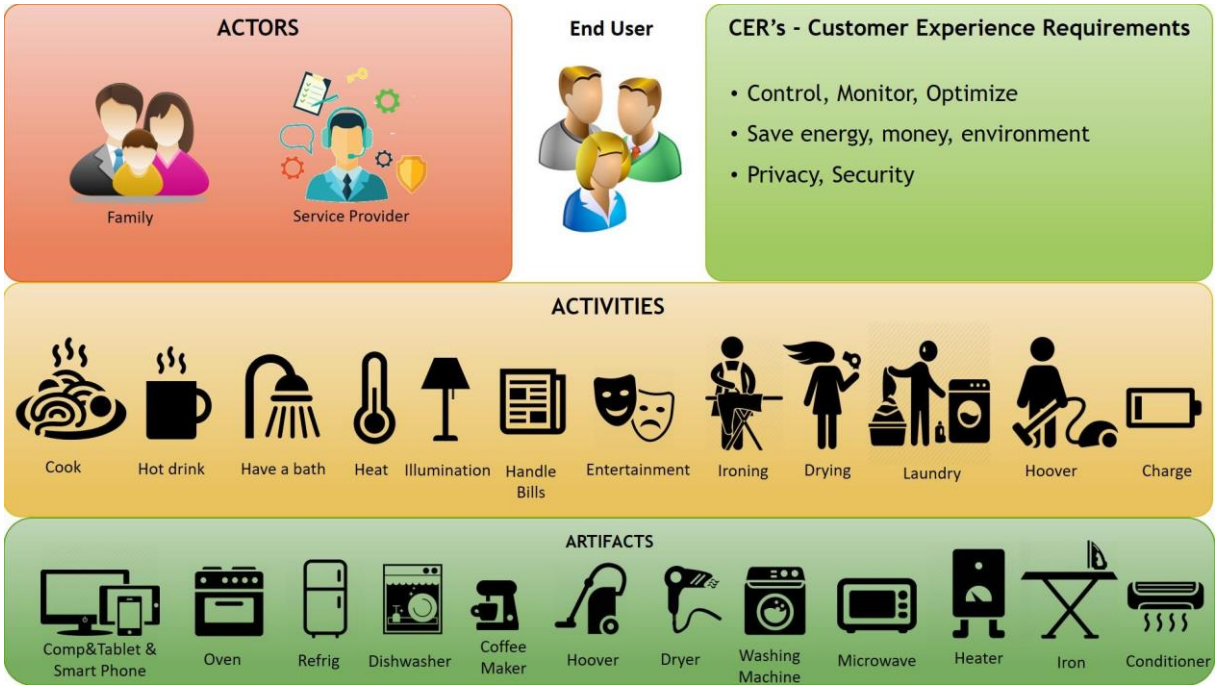


***Figure 12**: Customer Experience Modelling for HEMS (Source: Author)*

After Exploration process -Ideation phase was carried to identify a new service concept based on this previous stage. For this purpose, a set of ideas will be considered via brainstorming activity to generate and deploy the Customer Value Constellation (CVC) as a tool to systematize these ideas. Afterwards, we will define the service concept.

3.3.1 Customer Value Constellation (CVC)

Customer Value Constellation (CVC) is a valuable tool in MSD process to define the service concept. The CVC ensures a holistic view, by representing the set of service offerings and respective interrelationships that enable customers to co-create their value constellation experience for a given customer activity. Through CVC, companies can reconfigure their existing value propositions or create an innovative service concept (Patrício, L. et. al. 2011).

Some post-its recovered from the Brainstorming session performed during the Focus Group (see Figure 13). The participants were asked to write down their ideas about what they would like to see in their energy management system and pin up them on the board.

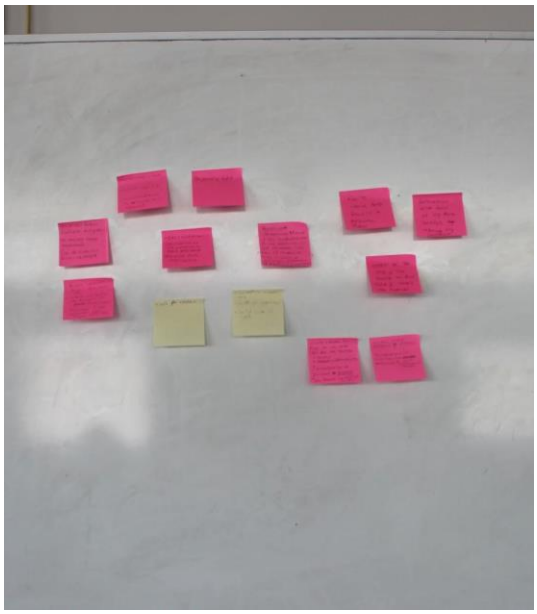


***Figure 13**: Post-its from the Focus Group*

After collecting the posters from the board, ideas were written down to build a customer value constellation. Table 5 shows the opinions and suggestions gathered form participants' posts.

***Table 5**: Ideation*

- Give the report in final of the year with all the savings: ● money ● environments with something of "you save X animals or plants" OR you reduce the warming in X %	- Reduce work learning feature - I put my preferences in the beginning in the register, and then IT manage it - With 3 notes or: ● financial improvement ● eco ● performance of equipment
- To check and provide a personal plan	-Daily performance -Classification of consumption of each appliance -Profile automatization
- Control every equipment in distance - New equipment to link old appliances to IOT (Internet of Things)	- Current usage in kWh - Current usage in € - Recommendations to become more efficient
-Interaction some of my home devices through my cell phone	- Output at the end of the month on how much save the planet
- Consumption compare daily - Switch on/off equipment - Cost per equipment	- Turn off devices - Pay attention to energy consumption - Use devices in different ours
- Indicate status of appliances - Check monthly energy consumption	- Daily energy price information

Finally, all ideas that acquired from interviews were transferred to Elementary CVC (see Figure 14). Considering it is a user centred service, the Figure 14 depicts the "End User" in the middle and the main activities around it. Sequentially, the main activities divided into sub activities. CVC was sketched as an iterative process.

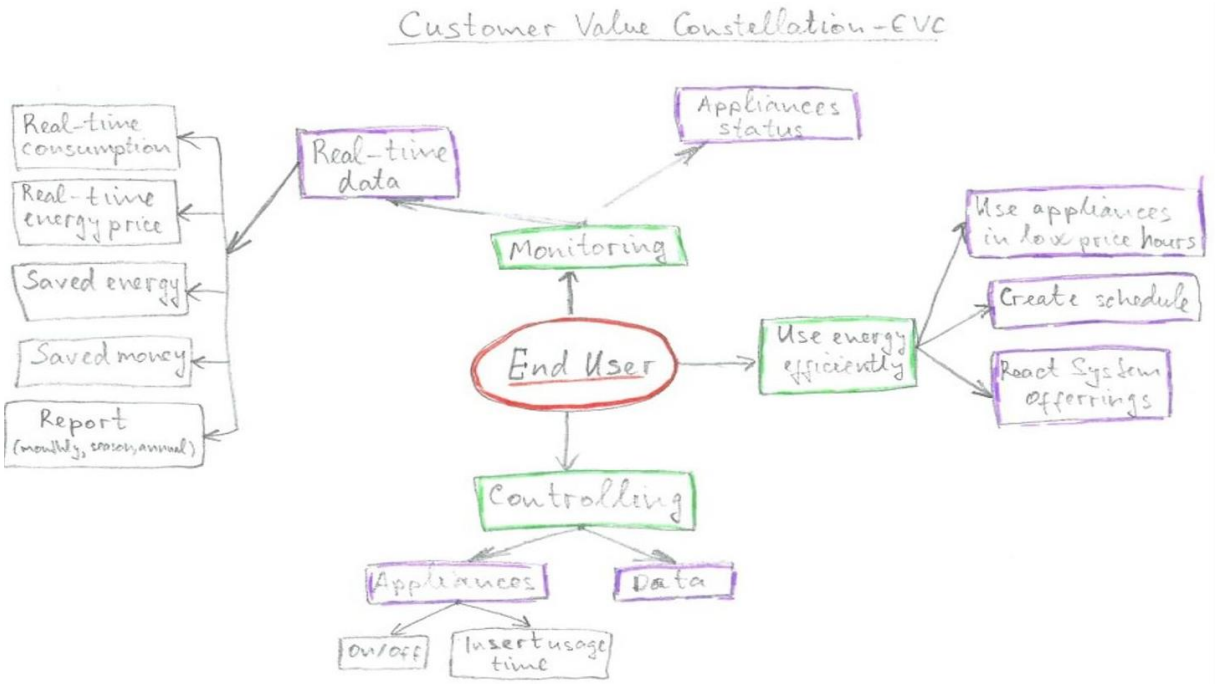


***Figure 14**: Elementary CVC*

An iterative process from elementary CVC to final CVC was carried out with regular updates based on information gathered from end users.

In Figure 15, CVC was designed for only existing mobile service in home energy management which was provided by EDP energy company in Portugal. This CVC supported us to develop a new service concept (Patrício, L. et. al. 2011).

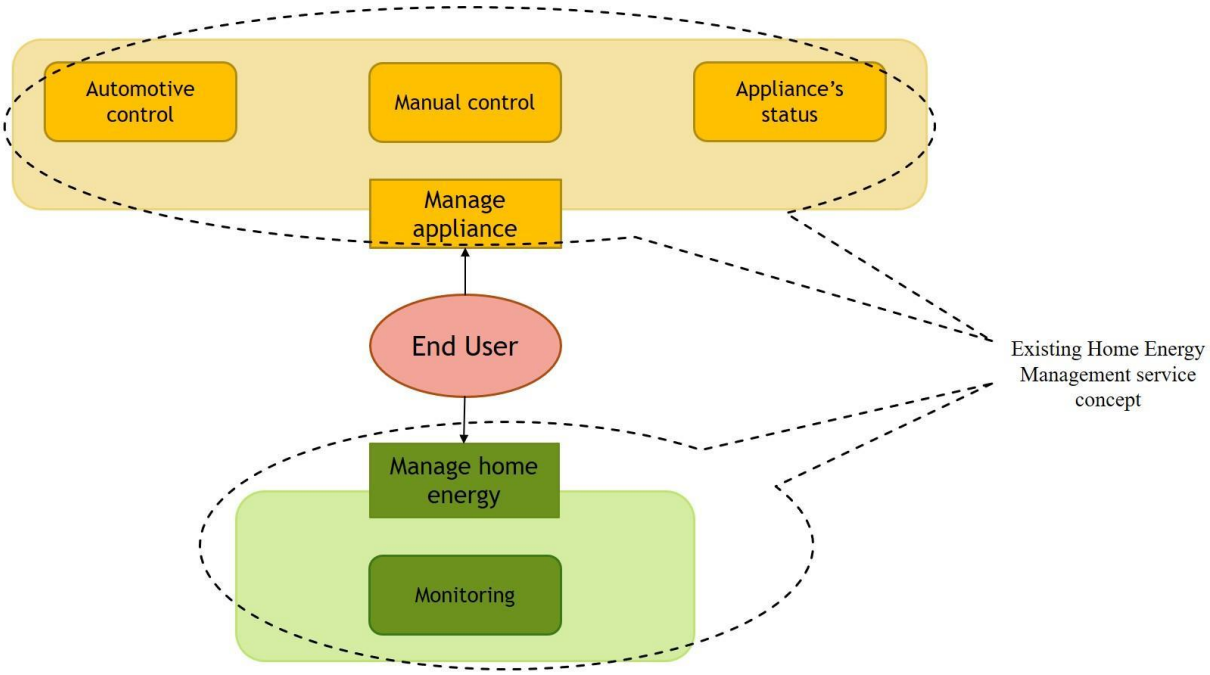


***Figure 15**: Existing service concept in HEMS*

As a consequence of customer experience study, the final CVC was designed (see Figure 16). In the development of our new service concept, integrated into the existing service concept we tried to give more competences to users in their energy managing issues. Thereby, in the final CVC**,** integrated new service concept was described. To be more precise, the main activities which are "Manage appliances" and "Manage home energy" centred around the "End User". Then, these main activities were clustered in sub processes to facilitate the service blueprint developing on the next stage.

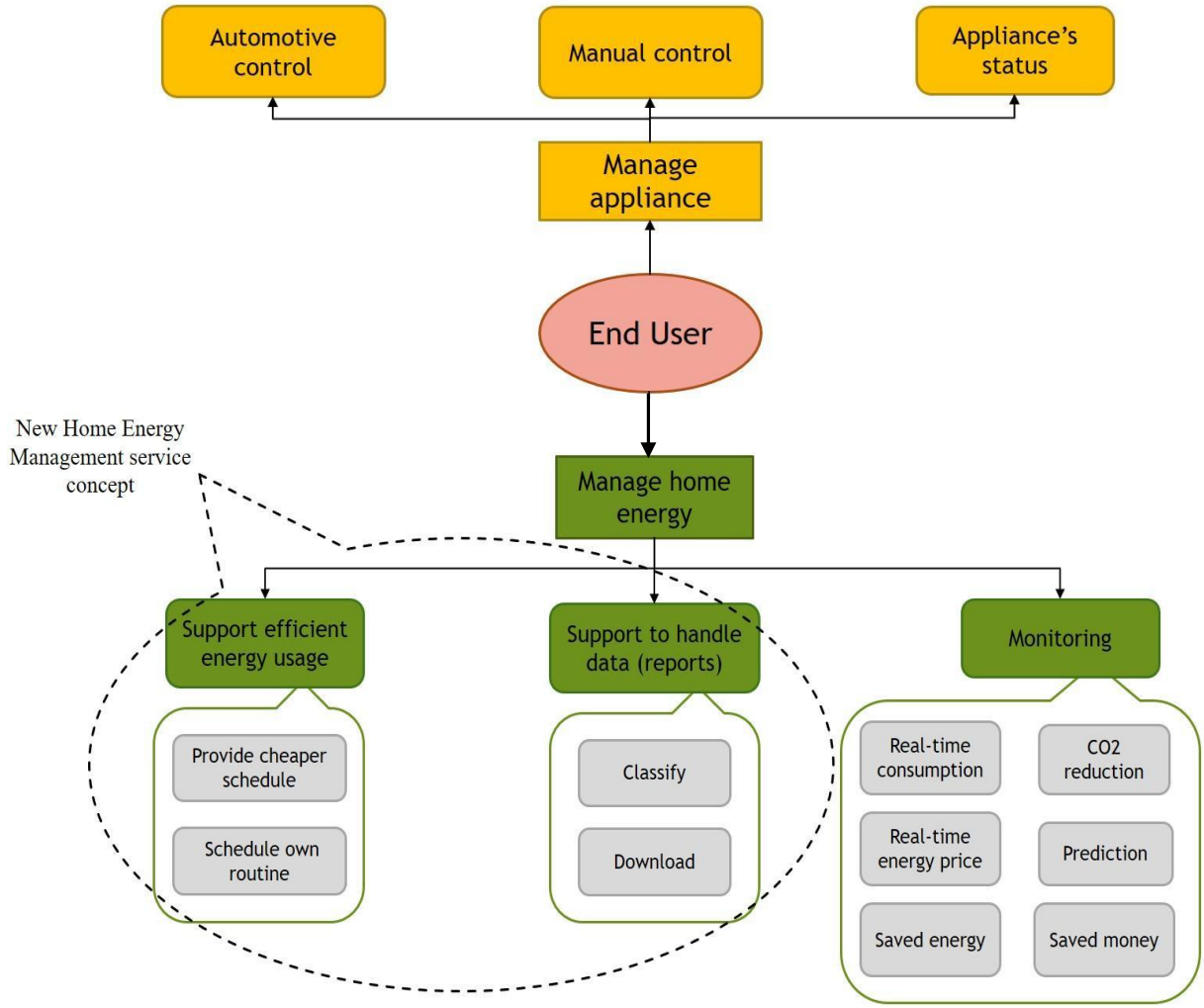


***Figure 16**: Integrated New service concept in HEMS*

Based on the final CVC (see Figure 16), "Manage home energy" activity was chosen for the next stage in the development of the Service Blueprint and Prototype.

3.4 Reflection

Following the Ideation phase, we are going to Reflection stage to visualize our service concept. In this part, we will deploy Service Experience Blueprint (SEB) and Service Experience Prototyping to make our service tangible and visible.

As Conclusion of this stage, we will build a mock-up based on service prototype which will represent our service offers like a final product.

3.4.1 Service Experience Blueprint (SEB)

> *"SEB builds on existing methods, joining the contributions of service management and software engineering to create a unifying method to address technology infusion into services."*
>
> *Patrício, L. et. al. (2008)*

Because of intangible nature of service, it is a challenge to touch it and make it visible for consumer. Nevertheless, according to Mary Jo Bitner et. al. (2008), another distinct character of service is its process trait. Through any service, customer implements flow of process to achieve any aimed goal. Somewhat, it is feasible to make the process visible illustrating involved actors, technologies, activities and interaction among them. As an advanced tool, SEB make any service process visible and helps understand designed service profoundly.

When start to build service blueprint (SB) it is necessary to identify service processes, sub-processes, actors and physical evidences (Bitner, M. J., et. al. 2008). Furthermore, there are several SB components namely actions, fail point, waiting point, start and end point. Moreover, according to service execution level there are frontstage which actions visible to customer while in backstage the actions are not visible to customer, interaction and visibility lines between activities and actors (Patrício, L. et. al. 2008).

Service Experience Blueprint was built for three activities: "Create routine", "Create cheaper schedule" and "Access data history" (see Figure 17 and Appendix C).

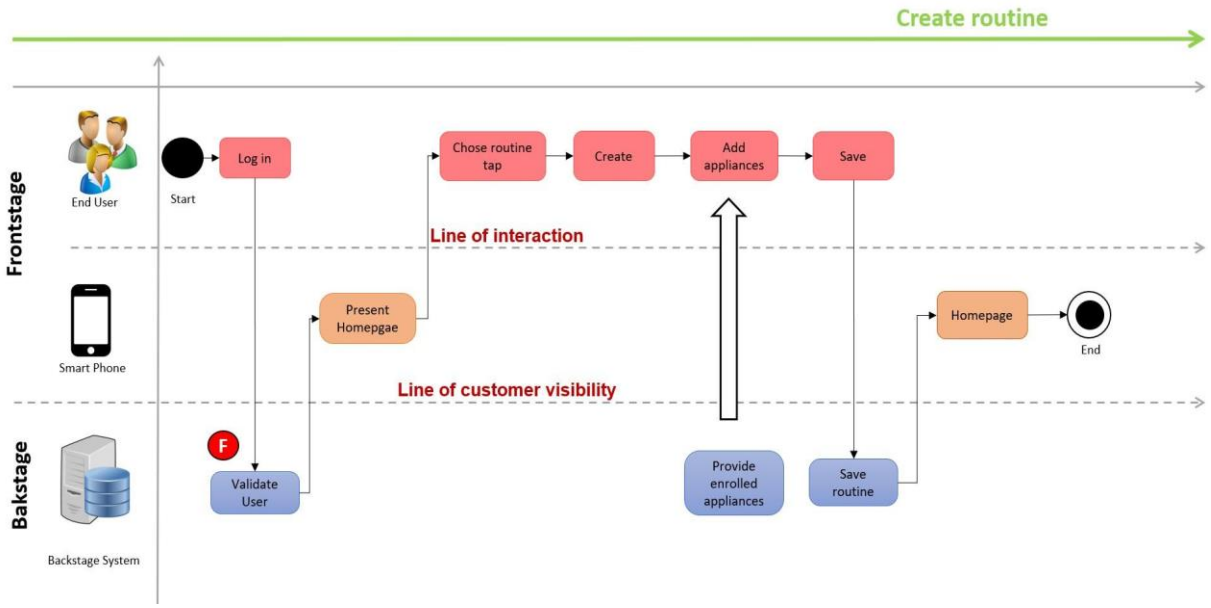
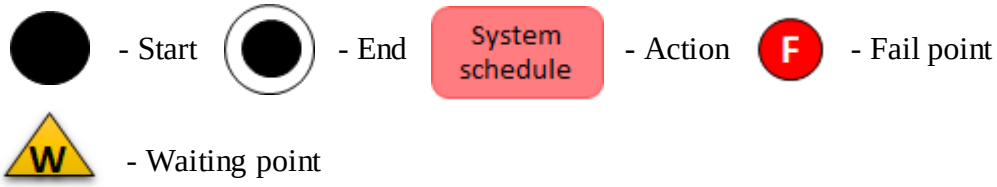


***Figure 17**: Service Experience Blueprint to Create Routine*



3.4.2 Service Experience Prototype (SXP)

> *"The things we have to learn before we do them, we learn by doing them."*
>
> *Aristotle*

As we reach the reflection stage, it is important to evaluate and validate the preliminary service designs.

According to Buchenau, M. et. al. (2000), Experience Prototyping simulates important aspects of entire interactions between people, places and objects as they unfold over time and have influence on the evaluation of ideas. They claim that Experience Prototyping can provide inspiration, confirmation or rejection of ideas based upon the quality of experience.

Prototypes are useful kits when discussing ideas with stakeholders, they are a communication tool among team members and are an effective way to make your idea tangible and visible. Generally, it is clustered into two classes namely Low-fidelity prototyping and High-fidelity prototyping. Low-fidelity prototyping is useful on an early stage because it is cheaper and simple, and most time it is different from the final product. It is predominantly used for exploration and allow the development of a service concept. Storyboarding, Sketching, Cards etc. are typical examples of such tools. In High-fidelity prototyping uses materials that you expect to be in final product and thus closer to a final product. Although it is expensive and time consuming but it offers full interaction with a sort-of a product (Preece, J. et. al. 2002). A study was made considering that prototyping a service is much more demanding than test only the interface.

In our study, we have chosen low-fidelity prototyping to make our service concept tangible and to test with users. Because it is a cheaper, simpler, faster and more suitable one in terms of time limitation of study.

Use of sketching is an aid in preliminary stage of the designing product. There are some attributes like cost, timeliness, quantity and disposability which differentiate it from prototype (Buxton, B. 2007, p. 139). Therefore, at an early stage of reflection we sketched some interfaces. Those sketches helped us to build better prototype. Figure 18 portrays an initial sketches of different service interface.

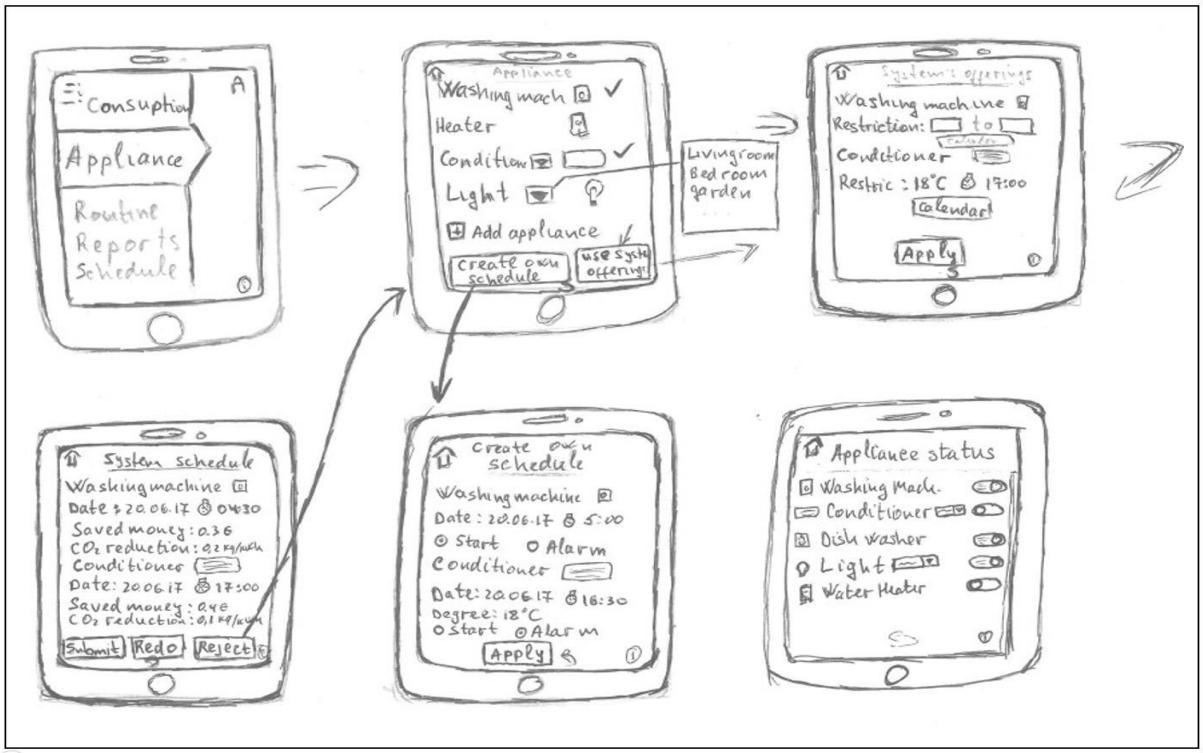


***Figure 18**: Interface sketches*

Following the drafting prototyping, in next step these sketches were converted into low-fidelity prototype (Appendix E). Figure 19 illustrates some service interface prototypes based on main service concept. Service offers cheaper schedule based on user preferences and then presents information about saved money and CO2 reduction. User could accept, reject or redo the system's offer.

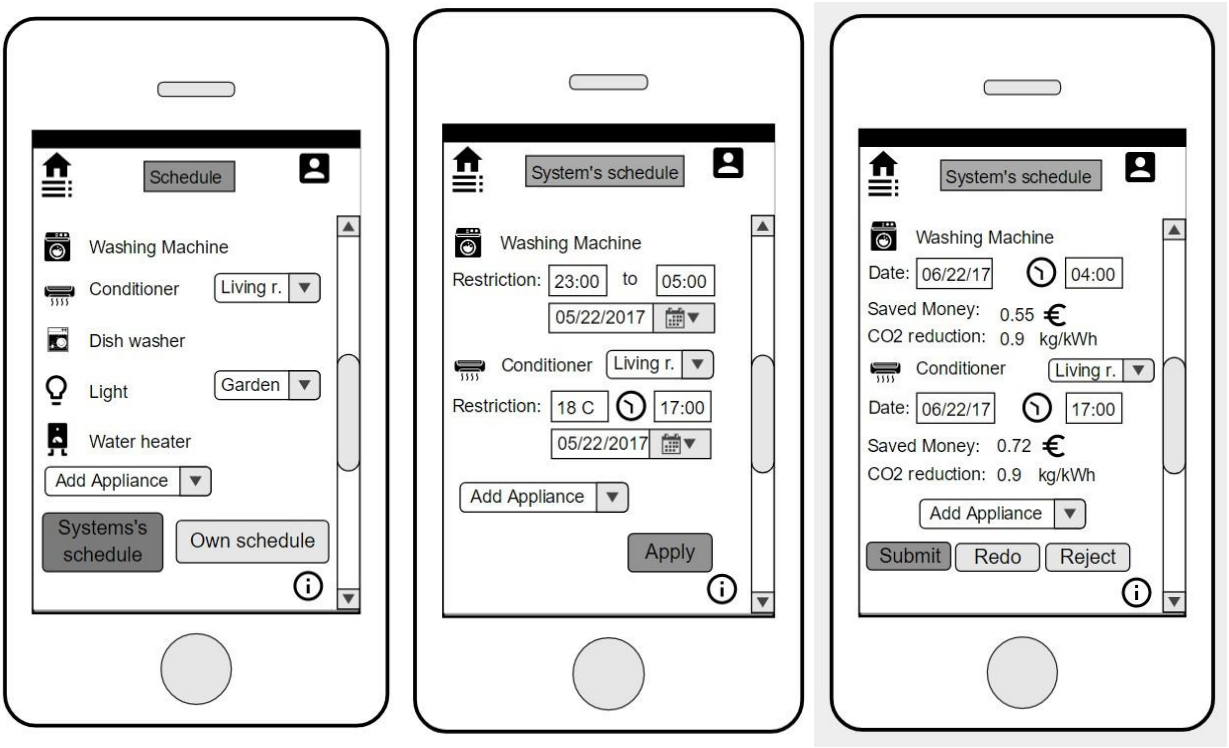


***Figure 19**: Low-fidelity Prototype*

The next phase consisted in converting the prototypes into mock-ups in order to make it tangible and to allow their testing with potential end users. This part was implemented using Marvel mobile application. This application allows to animate the sketches and to test them. In Marvel mobile application, prototype photos can be added or sketch directly. Then making artificial buttons you can build link between different interface and run your interfaces (see Figure 20).

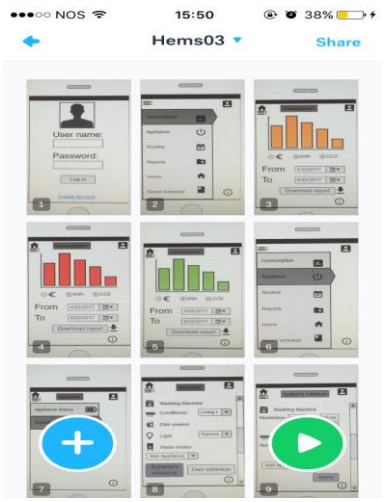


***Figure 20**: Marvell mobile application interface*

Figure 21 depicts the interaction of users with service interface. In the probing process, the users were allowed to use it without intervention and they were observed. Mainly they gave feedbacks in two directions: about service features and about interface design. During the testing process user's feedbacks and doubts were noted for evaluating.

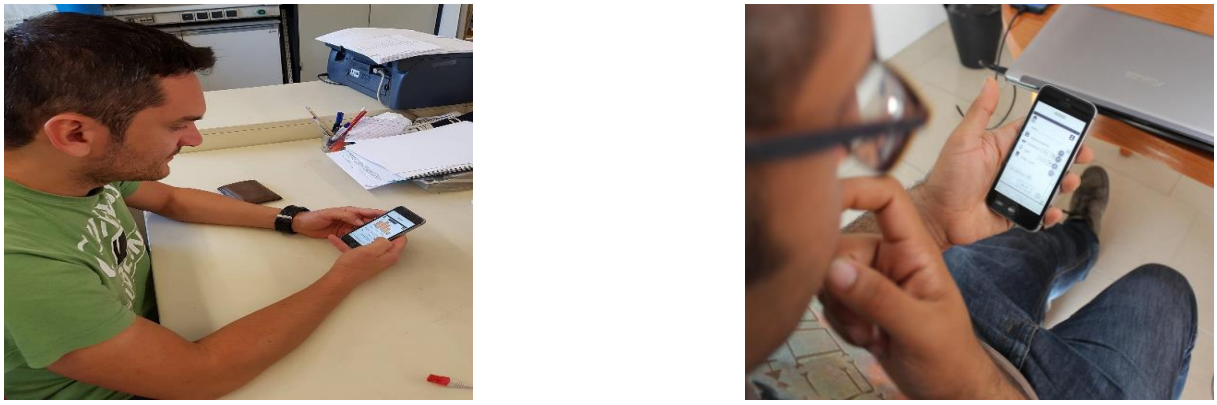


***Figure 21**: Testing Mock-ups*

Table 3 describe the feedbacks that acquired during the testing of mock-ups wit users. We clustered these feedbacks into two categories: 1) Service concept 2) Interface aspect

***Table 6**: Users' feedback*

Service aspect	Interface aspect
"I think it is a good app...it is a simple with most important features…"	"could be better if you put different colours in design…"
"For me is good...cause have basic information, features…"	"a little confused in sequence of interfaces..."
"I want to see something about renewable energy"	"make it more interactive and attractive!"
"This app is an important step for future energy services" "App should give some notification about situation regarding"	----------

Service experience prototyping (SXP) based on storyboard provides more holistic view about service and its environment that is implemented. User experience prototyping (UXP) depicts

interaction between user and interface while SXP represents whole service process including humans, technology and space where the service is delivered (Sarmento, T. 2013). Considering this feature of SXP storyboard we are going to render one scenario that illustrates the flow of event implemented by user.

In Figure 22, we depicted the simple scenario by Storyboard in order "to help jump across the chasm between understanding users and solving their problems" (Goodwin, K. 2009, p. 455). The Storyboard illustrates one welfare problem related to expenses and its solution based on designed service. "Joao" and "Ana" are spouses and our personas in this scenario. Flow of scenario is taking place from left to right and from top to bottom.

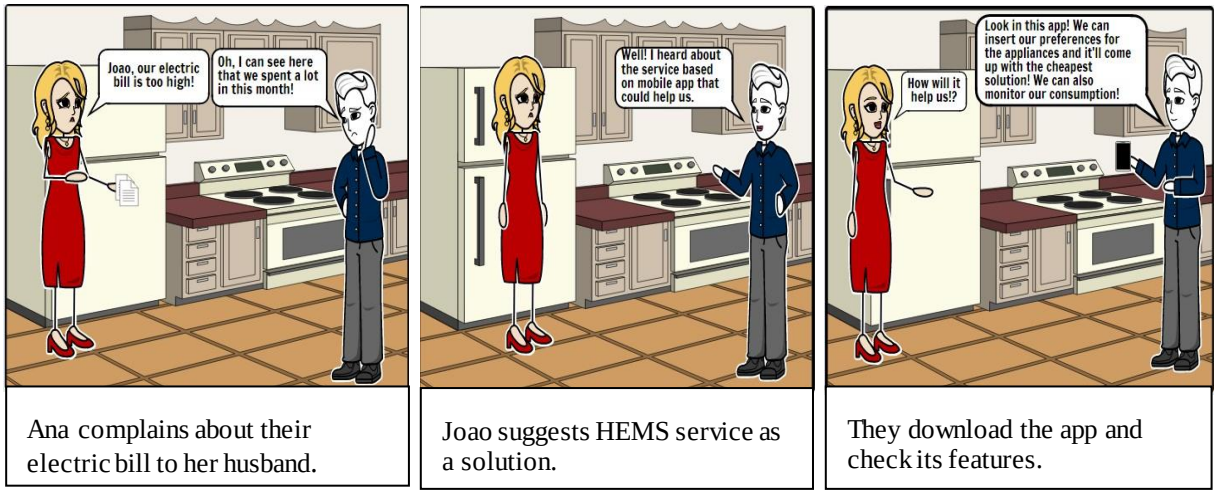


***Figure 22**: Storyboard*

4. Discussion and Implications

The main objectives of the work presented in this thesis are to gain insights about customer experience and find requisites to support end users in efficiently manage their energy use and what we have done to reach these goals.

Along the study an effort was put in finding a suitable approach to proposed problem and ensure some contributions. The first one is our "Aggregate Energy Management Service Design Stakeholder Map" (see Figure 2) which depicts all stakeholders, as relevant figures, in the design of energy management services. This map creates global view and presents the need of stakeholders, respectively in the centre more important actors which are households and other figures that have an influence on design process. This is crucial to know who must be involved to design process and their importance.

In the literature review, gaps were identified within the current work which guided us along our study. These gaps predominantly consist of lack of a holistic view in terms of designing Energy Management Services. It was highlighted the design process, as well as the different components that should be considered, namely customer experience & behaviour, service design methods, interaction design etc. In our study, we strived to build aggregate approach and to fill this gap.

Study customer experience and understand their needs stand on the base of customer centric services. Taking this factor into account, on Exploration stage we tried to choose more appropriate methods to support us to map and gain relevant insights about customer experience. Thereby, doing individual and group interviews we gathered data. Significant findings in this session, are insights about customer experience which in report we presented them as an input to map a "Customer Experience Modelling" (CEM) (see Figure 8). More specifically, CEM created universal portrait that assisted us to get insights about customer requirements, activities, artifacts and technologies that they might use.

As a result of the customer experience study, "Customer Value Constellation" (CVC) was mapped (see Figure 9). CVC supported us to evolve ascertained insights into a new service concept. CVC depicted our new service concept with links between End User and activities that provided by our service.

Next yield of our study is Service Blueprint (SB) that we showed the flow of activities with actors and technologies based on new service concept (see Figure 14 and Appendix C). Following the SB, we strived to build prototypes and Mock-ups in order make it tangible for customer and test it. Results of this stage was demonstrated in Appendix E.

4.1 Findings regard the Portuguese context

In the modern world, energy management is one of the most discussed issues. We strived to explore this topic in Portuguese context. As a result, we revealed two main inferences from customer study.

Former outcome is people are willing to do behavioural changes using such type of services to get financial benefits. Sometimes this concern was ascribed to high or incremental energy price in Portugal.

> *"I am willing to do possible changes to obtain financial benefits and environmental"*
>
> *Female, 53 years old*

Latter important issue is people's environmental concerns. Participants frequently mentioned about green energy use and its contribution to environment. What we realized is almost all participants conceive renewable energy sources as a part of their future home energy system.

Although, the size of research sample was not so large, the results from data analysis gave us initial perception about customer's behaviour and their tendency which supported us to design a new service and its prototype.

5. Conclusion

The work presented in this thesis addresses the design of energy management services in addressing the challenges of promoting the active participation of end-users by raising awareness to the energy use topic and find appropriate strategies to maximize their engagement.

Thereby, as the result of customer experience study, we found some requisites and developed a new service concept. Based on this new service concept we designed prototypes and Mock-ups for validation and evaluation.

In addition, the contribution to literature is our holistic approach to energy management service design process, which was mentioned as the main gap in the literature review. This holistic view is to involve appropriate service design phases and tools to design process. Furthermore, as a complementary phase of this holistic approach, it is useful to collaborate engineers from problem emerging field.

Another interesting point should be noted is the value added by user. The role of end user in service co-creation process is their intensive interaction with service and their reactions to system's offers. Based on this interaction, service providers can predict energy consumption and act in energy market more precisely. In addition, we would like to highlight its advantage in terms of energy logistics and DR concept. Reducing loads in peak hours Energy Providers can decrease energy losses in energy logistics and satisfy the user's demand uninterruptedly.

5.1 Future Research and Limitations

Regarding future researches, some clues were found within this study: As mentioned in the first chapter, the proliferation of renewable energy use makes to think about a new customer segment and more aggregated service concept. It arises the necessity to shift research segmentation from consumers to prosumers, who produce and consume energy, and design relevant service for them.

On the other hand, for further study the "rebound effect" (Gillingham, K. et. al 2015) should be considered in terms of energy efficiency improvement. Customers could consume more energy if they have more energy saving. Related to this concept, researchers could figure out the issue by responding the question: If customers get more energy saving how will they react it?

Within the research process predominantly two limitations were faced. Considering that the researcher is an English spoken person, the language became challenge in some issues. Especially, this restriction appeared during the data collection. Because the study was based on Portuguese context and Portuguese households were studied. Sometimes it was difficult to have access to English spoken users.

Latter obstacle was time limitation, which narrowed the research's scope. This limitation occurred more in the data collection and probing processes. Thereby, more sample access and test prototype with a satisfied number of users was challenging.

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APPENDIX A: Interview Question

1. Are you responsible for electricity bill at home?

   Yes No

2. Do you normally pay attention to your energy consumption? (to save - switching off the lights when leaving the room, monitor etc.)

3. Do you have any remote-control appliances in your home?

   Yes No Do not know

4. Do you use any HEMS in your home?

   Yes No Do not know

5. Do you have an idea of how much your household spends monthly on electricity (in €)?

6. Do you have a stable routine during the weekdays?

7. How do you usually spend your weekends?

8. What is your Energy Provider and type of contract with your Energy provider?

9. What factors do influence on your energy consumption behaviour?

   How much do you care with energy consumption? Would you be able to make some behavioural changes to have a more efficient consumption?

10. How much do you think you benefit from flexible tariffs (if you have)?

Not at all	Slightly	Moderately	Very	Extremely

11. How would you describe your knowledge of smart energy management system?

Low Average Good

12. How important are the following reasons for your decision to install an HEMS?

Reducing energy bill

Not important	Slightly important	Moderately important	Important	Very important

Being part of an innovative project

Not important	Slightly important	Moderately important	Important	Very important

The possibility of getting additional services/products in bundle

Not important	Slightly important	Moderately important	Important	Very important

Gaining more control over my energy bill

Not important	Slightly important	Moderately important	Important	Very important

Getting attractive hi-tech devices/appliances

Not important	Slightly important	Moderately important	Important	Very important

Having the ability of comparing own energy consumption with others

Not important	Slightly important	Moderately important	Important	Very important

Benefits for the environment (reduction in CO2 emission)

Not important	Slightly important	Moderately important	Important	Very important

Contributing to a safer and more stable energy grid (reducing the likelihood of outages or blackouts)

Not important	Slightly important	Moderately important	Important	Very important

APPENDIX B: Focus Group Question Structure

Ice break question:

How do you imagine dealing with your home energy system in the 2030?

Engagement question:

1. What was your perception about HEMS till this presentation?

2. These days we use mobile apps to everything… And probably we already have many mobile solutions to energy management … So, I would like to ask you What kind of mobile services do you use more? And why?

***Keywords*:** which one are you *using currently, your favourites, how often, your reaction, belief to app's offers, pros&cons*

Exploration questions:

3. Do you usually pay attention to energy consumption? Do you know the difference between the energy consumption in a weekday or week-end day? In summer or winter time?

Keywords: *how (your behaviour), try to save energy, check bills each month and compare them.*

4. Have you ever felt the need of having energy management system for your home?

Key words: *describe any situation, what type of service you need then.*

5. Do you have daily routines? How do you think these routines or absence of routines might affect your use of energy at home? Do you have stable routine in both weekdays and weekends?

Keywords: describe any *daily routine, roughly pattern of usage of appliance*.

6. What factors do influence on your energy consumption behaviour?

Keywords: *daily routine, work, family, relatives, friends, income etc.*

- How much do you care with energy consumption? Would you be able to make some behavioural changes to have a more efficient consumption?

Keywords: *if you could gain..financial returning, environmental issues, comfortable etc.*

7. Would you mind writing down at least 3 service features that you would like to see in

your HEMS interface?

Exit question:

8. Is there anything else you would like to say about this energy management service topic?

Keywords: service features, any suggestion.

APPENDIX C: Invitation Card for Focus Group

ENERGY MANAGEMENT SERVICE DESIGN
"FOCUS GROUP" EVENT

28.APRIL.2017
1ST PART - 10^{00} -11^{00} ENGLISH SPOKEN
2ND PART - 11^{30}- 12^{30} PORTUGUESE SPOKEN
PORTO INNOVATION HUB
R. DR. ANTÓNIO LUÍS GOMES, 4000-010 PORTO

I would like to invite you for a round table moderated by Emil Goyushzada, Master candidate of FEUP. The purpose of this group conversation is to try and understand customer behavior considering energy consumption. The 1st part of event dedicated to English speaking people while 2nd part to Portuguese speaking people. The information learned in the focus groups will be used to design energy management service to support active participation of customers.

You can choose whether or not to participate in the focus group and stop it at any time. Although the focus group will be tape recorded, your responses will remain anonymous and no names will be mentioned in the report. There are no right or wrong answers to the focus group questions. We want to hear many different viewpoints and would like to hear from everyone. If you want to be part of this innovative project, we will be pleased! We kindly ask to confirm your acceptance for this date. Thanks in advance.

Yours sincerely,
Emil Goyushzada

FOR MORE INFORMATION CONTACT: EMIL GOYUSHZADA
EMAIL: GOYUSHZADAEMIL@GMAIL.COM TEL:+351934941844

ENERGY MANAGEMENT SERVICE DESIGN
EVENTO "FOCUS GROUP"

28.ABRIL.2017
1ª PARTE - 10^{00} -11^{00} FALADO EM INGLÊS
2ª PARTE - 11^{30}- 12^{30} FALADO EM PORTUGUÊS
PORTO INNOVATION HUB
R. DR. ANTÓNIO LUÍS GOMES, 4000-010 PORTO

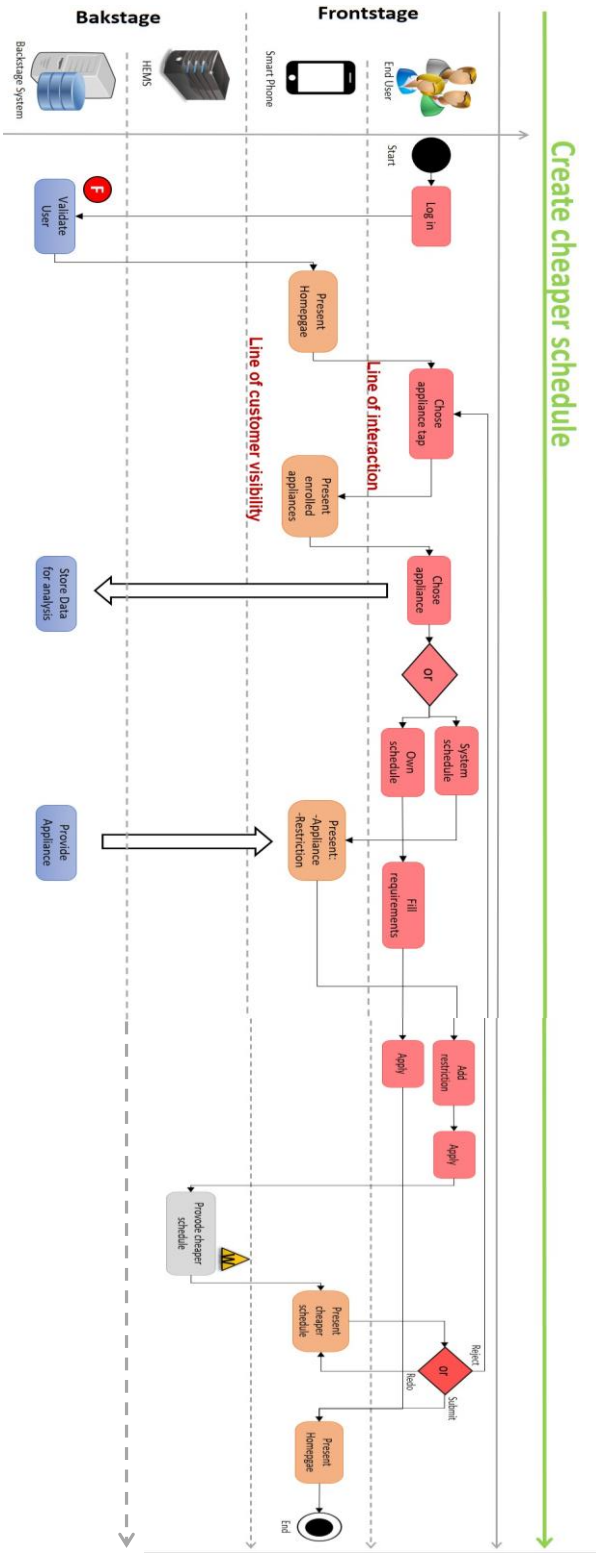
Gostaria de convidá-lo para uma mesa redonda moderada por Emil Goyushzada, mestre candidato da FEUP. O objetivo desta conversa em grupo é tentar entender o comportamento do cliente considerando o consumo de energia. A 1ª parte do evento é dedicada a pessoas que falam inglês, enquanto a segunda parte será dedicada a pessoas que falam português. As informações aprendidas nos grupos focais serão usadas para projetar serviços de gerenciamento de energia para apoiar a participação ativa dos clientes.

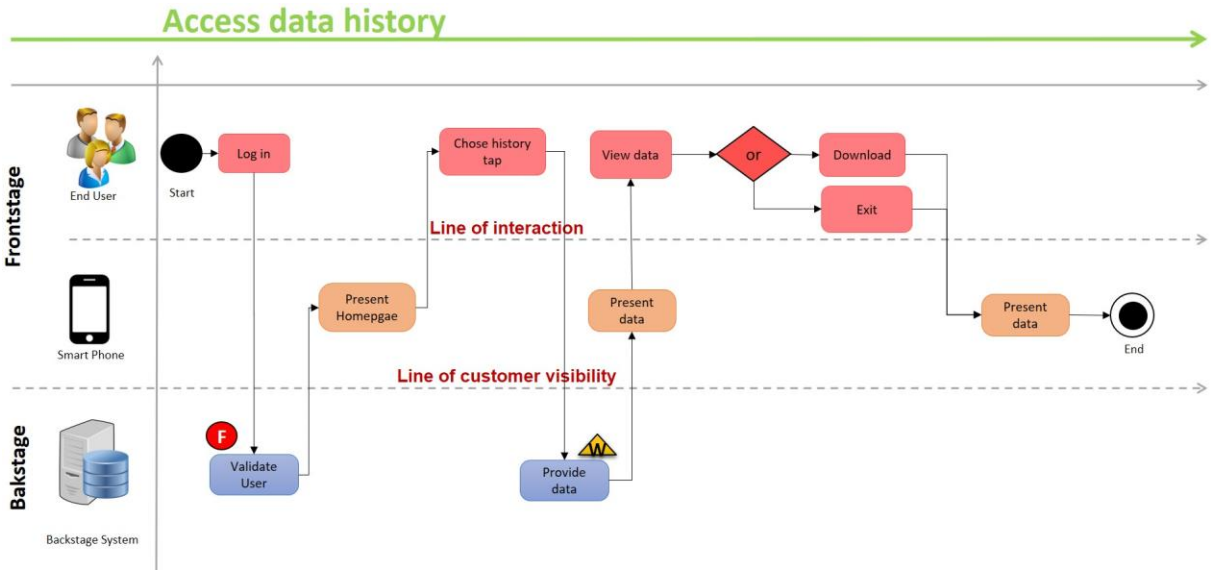
Pode optar por participar ou não no grupo focal e parar a qualquer momento. Embora o grupo focal seja gravado, as suas respostas permanecerão anónimas e nenhum nome será mencionado no relatório. Não há respostas certas ou erradas para as perguntas dos grupos focais. Queremos ouvir muitos pontos de vista diferentes e gostaríamos de ouvir de todos. Se quiser fazer parte deste projeto inovador, ficaremos satisfeitos! Pedimos-lhe para confirmar a sua aceitação para esta data. Desde já, obrigado.

Com os melhores cumprimentos,
Emil Goyushzada

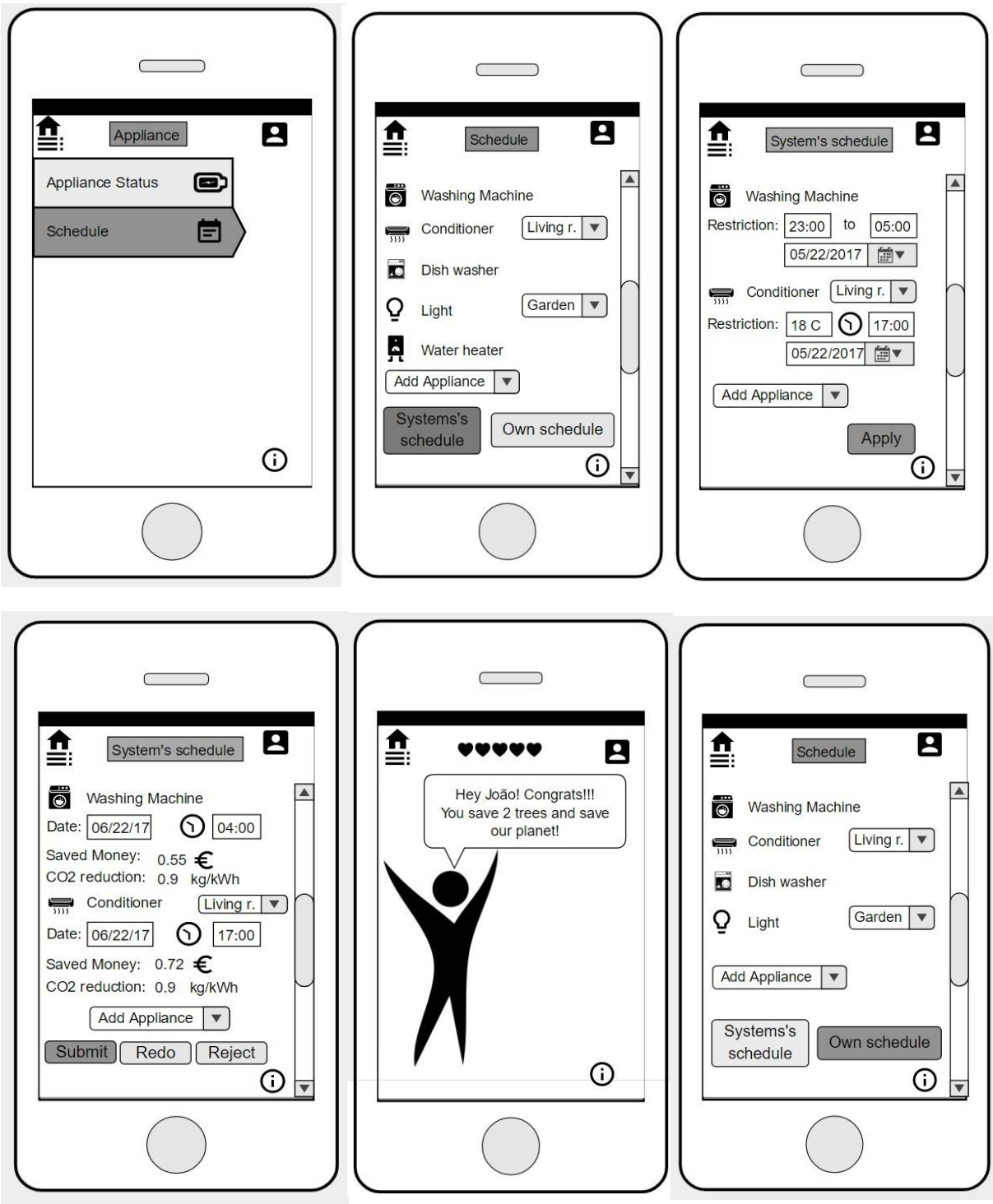
PARA MAIS INFORMAÇÕES ENTRE EM CONTATO: EMIL GOYUSHZADA EMAIL:
EMILGOYUSHZADA@GMAIL.COM TEL:+351934941844

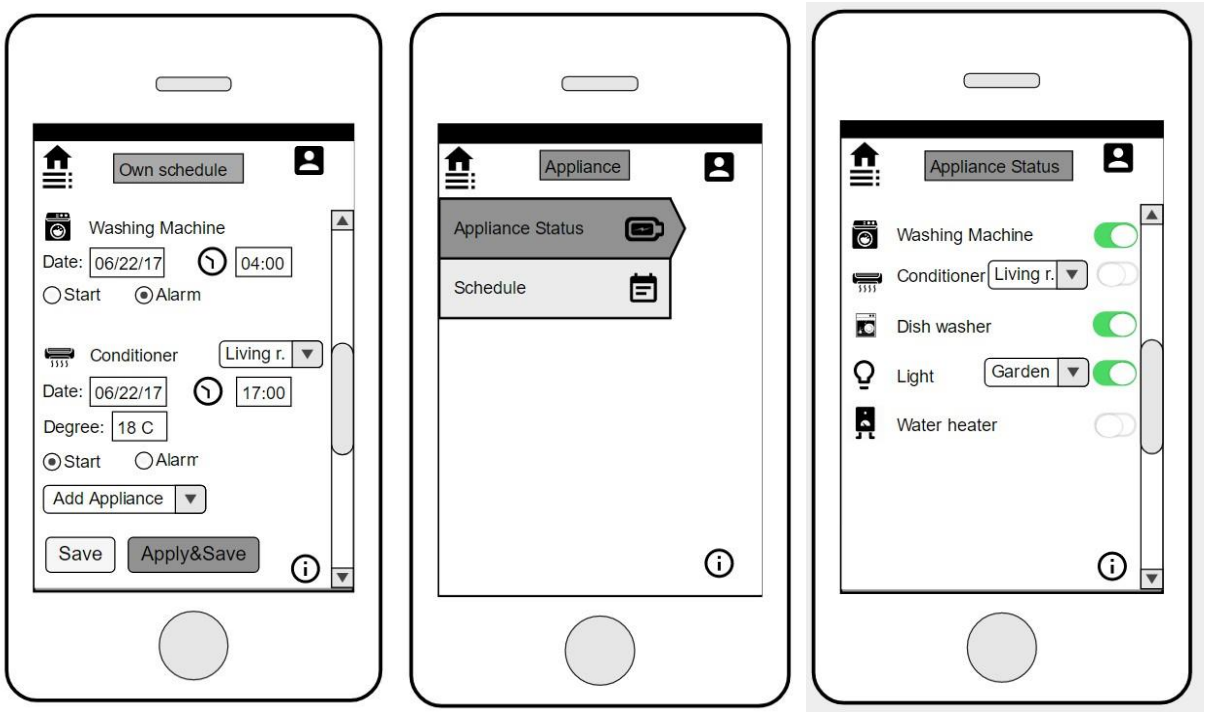
APPENDIX D: Service Blueprint

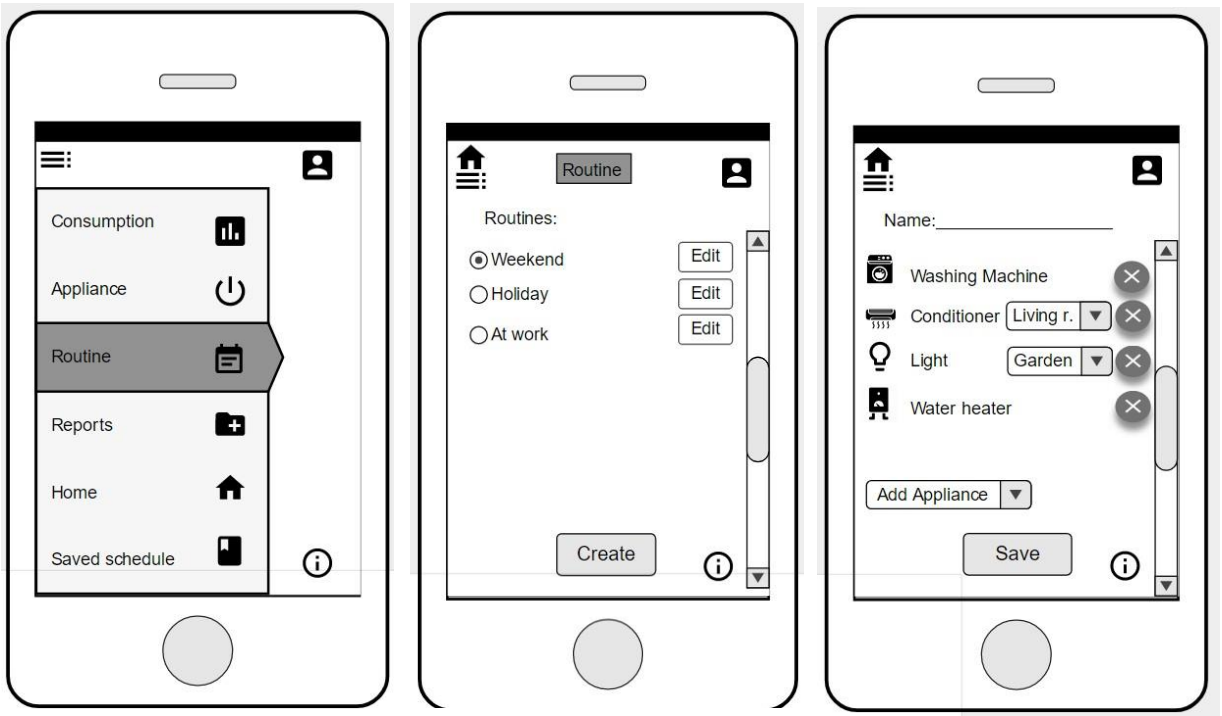



Access data history
Frontstage
End User
Start
Log in
Chose history tap
View data
or
Download
Exit
Line of interaction
Present Homepgae
Present data
Present data
End
Smart Phone
Line of customer visibility
Bakstage
Validate User
Provide data
Backstage System

APPENDIX : Prototype


Appliance
Appliance Status
Schedule
Schedule
Washing Machine
Conditioner
Living r.
Dish washer
Light
Garden
Water heater
Add Appliance
Systems's schedule
Own schedule
System's schedule
Washing Machine
Restriction: 23:00 to 05:00
05/22/2017
Conditioner
Living r.
Restriction: 18 C 17:00
05/22/2017
Add Appliance
Apply
System's schedule
Washing Machine
Date: 06/22/17 04:00
Saved Money: 0.55 €
CO2 reduction: 0.9 kg/kWh
Conditioner
Living r.
Date: 06/22/17 17:00
Saved Money: 0.72 €
CO2 reduction: 0.9 kg/kWh
Add Appliance
Submit
Redo
Reject
Hey João! Congrats!!!
You save 2 trees and save our planet!
Schedule
Washing Machine
Conditioner
Living r.
Dish washer
Light
Garden
Add Appliance
Systems's schedule
Own schedule


Own schedule
Washing Machine
Date: 06/22/17
04:00
Start
Alarm
Conditioner
Living r.
Date: 06/22/17
17:00
Degree: 18 C
Start
Alarm
Add Appliance
Save
Apply&Save
Appliance
Appliance Status
Schedule
Appliance Status
Washing Machine
Conditioner
Living r.
Dish washer
Light
Garden
Water heater


Consumption
Appliance
Routine
Reports
Home
Saved schedule
Routine
Routines:
Weekend
Holiday
At work
Edit
Edit
Edit
Create
Name:
Washing Machine
Conditioner
Living r.
Light
Garden
Water heater
Add Appliance
Save


Consumption
kWh
CO2
4/22/2017
6/22/2017
Download report
Consumption
Appliance
kWh
CO2
4/22/2017
6/22/2017
Download report