MESG

MESTRADO EM ENGENHARIA DE SERVIÇOS E GESTÃO

Electric Mobility Services for Commercial Buildings

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Master Thesis

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2019-09-23

Abstract

Electric vehicle sales' growth represents a challenge to the electric mobility industry. As it will be shown through this work, the offer of electric mobility services such as charging services, do not meet demand. Adapting to this mobility model presents several opportunities to develop new innovative solutions. The presence of parking areas and an electric infrastructure of greater dimension allows the integration of those. The present study aims 1) to design an electric mobility charging service on a supermarket infrastructure; 2) to develop and follow-up a service design method that fits these problem specificities.

The Design Science Research was the methodology utilized to develop the objetives. It was performed with nineteen electric vehicle users, from Portugal. The data was collected with two sets of semi-structured interviews and on a later co-creative workshop session with four electric vehicle users. The study uses a service design method which considers the customer as the starting point for launching a new service. The design process is divided into three stages: a) the Exploration stage, where the study of the customer experience was undertaken. The design tools used to explore and understand people involved in the service context were stakeholder map and personas. To map the user experience it was used customer journeys maps and customer experience modelling; b) in the Ideation phase, it was designed the Customer Value Constellation to support the design of the service concept, to complement the results of this stage, the Service System Architecture that represent the main ativitities undertaken by customer and how the service system can support those, and the Service System Navigation was designed to represent a dynamic representation of the paths available for the customer through the channels of the service system; c) in the reflection and prototyping stage, service concepts were prototyped, enabling also the visualization of the service system, through storyboards and mock-ups.

The new service designed in this project provides to the users shopping, parking, electric vehicle charging management, availability, security and lowcost electric vehicle charging. In addition, it can offer client support, e-roaming, reservation service, special promotions, e-car washing, and users' connectivity with the commercial building.

This solution serves as a launching pad to implement an innovative electric mobility service. Its peculiarity is the focus on answering the Service Design questions of what's the best path from the customer experience understanding to how new innovative service concepts are developed. Hence, this project presents the models mentioned above and clarifies the proposed service solutions.

Keywords: Service, Service Design, Electric Mobility Services, Electric Vehicle Charging Services, Commercial Buildings.

Resumo

O crescimento das vendas de veículos elétricos representa u desafio para a indústria da mobilidade elétrica. Como será explicitado neste projeto, a oferta de serviços de mobilidade elétrica tal como serviços de carregamento, não correspondem à procura. A adaptação a este modelo de mobilidade apresenta várias oportunidades para que novas soluções inovadoras sejam desenvolvidas. A presença de locais de parqueamento e infraestruturas elétricas de grande dimensão permitem a respetiva integração. O presente estudo visa, por um lado, o desenho de um serviço de carregamento de veículos elétricos numa infraestrutura de um supermercado. Por outro lado, visa o desenvolvimento de um método de *service design* que se enquadre com as especificidades do problema.

Este estudo utiliza um método de *service design* que coloca o foco no cliente na fase inicial para a criação de um novo serviço. Este, foi realizado com dezanove utilizadores de veículos elétricos, em Portugal. Os dados foram colecionados com dois grupos de entrevistas semiestruturadas e a partir de uma sessão de workshop de cocriação, com 4 utilizadores de veículos elétricos. O processo de desenho encontra-se dividido em três etapas: a) Exploração, onde o estudo da experiência do consumidor foi realizado. As ferramentas de desenho usadas para explorar e entender as pessoas envolvidas no estudo foram o *Stakeholder Map* e as *Personas*. Para mapear a experiência do utilizador foram usadas *Customer Journey Maps* e *Customer Experience Modelling*; b) na fase de Ideação, foi desenhado a *Customer Value Constellation* que suporta o desenho do conceito do serviço, para complementar os resultados desta etapa, foram igualmente desenhados o *Service System Architecture* que representa o sistema do serviço de forma estática e o *Service System Navigation*, que representa de uma forma dinâmica os caminhos disponíveis que o consumidor poderá tomar, e como o Sistema do serviço apoia estas atividades; c) na etapa referente à reflexão, os conceitos do serviço são prototipados, permitindo assim a visualização clara do sistema do serviço, usando ferramentas como *storyboards* e *mock-ups.*

O novo serviço desenhado neste projeto fornece aos clientes fazer compras, estacionamento, gestão do carregamento de veículos elétricos, disponibilidade, segurança, carregamento de veículos elétricos *lowcost*, oferece igualmente, suporte ao cliente, e-roaming, promoções especiais para clientes que usufruam do serviço de carregamento, lavagem automática de veículos elétricos e conectividade entre o supermercado, a estação de carregamento e utilizadores.

A solução proposta apresenta-se como uma rampa de lançamento para a implementação de serviços de carregamento de veículos elétricos. A sua peculiaridade é o foco na resposta a questões de *Service Design*, sobre qual o melhor caminho entre o entendimento da experiência do consumidor e como novos e inovadores conceitos de serviço podem ser desenvolvidos. Para terminar, este estudo apresenta o modelo acima mencionado e clarifica quais as soluções do serviço propostas.

Palavras-Chave: Serviço, Service Design, Serviços de Mobilidade Elétrica, Serviços de Carregamento de Veículos Elétricos, Estabelecimentos Comerciais.

Acknowledgments

In first place, I thank to my parents, who taught me the importance of family and the path of honesty and who allowed me to achieve this goal.

I want to thank my supervisor, Lia Patrício, for the support and orientation throughout the project. I also want to thank my joint supervisor, David Rua, for the guidance and provision of the necessary information to the completion of this project.

I also would like to thank all the participants in this project, for their availability and openness.

I am very grateful to my brother, Saulo, for the continuous support, for all the motivation and concern in this project, and for being my biggest pillar throughout all my life.

Finally, I want to thank all my friends that made this moment possible. Thank you for all your support, cheering and friendship, not only during this phase but also for many years.

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API	Application Programming Interface
BEV	Battery Electric Vehicle
CEM	Customer Experience Modelling
CJ	Customer Journey
CS	Charging Station
DGEG	General Directorate for Energy and Geology
DSR	Design Science Research
EM	Electric Mobility
EMC	Authorization Holders of Electric Mobility Commercialization
EMN	Electric Mobility Network
ERSE	Energy Services Regulatory Authority
EV	Electric Vehicle
EVU	Electric Vehicle User
FCEV	Fuel Cell Electrical Vehicle
OPC	Operator of the Charging Stations
PEV	Pure Electric Vehicle
PHEV	Plug-in Hybrid Vehicle
RFID	Radio Frequency Identification Technology
SD	Service Design
SSA	Service System Architecture
SSN	Service System Navigation
TVDE	Individual and paid passenger transport in vehicles based on an electronic platform
V2G	Vehicle-to-Grid

Introduction

The first chapter of the thesis addresses the context of the project, the motivations and objectives topic of this Master's thesis. It briefly presents the project background and motivation, main research objectives, research questions that allow conducting the research, as well as the project report structure.

1.1 Project background

Climate change and the predicted exhaustion of fossil fuel resources is concerning political, economic and social issues. A large number of strategies are being implemented to circumvent this context. Electric mobility (EM) is an important contribution to solve the problems stated before by increasing electric efficiency in transports and reducing CO2 emissions. Electric Vehicles (EV) allow, due to its flexibility, the utilization of reneweble sources, includind photovoltaic panels. Aiming for this contribution to be significative, more incentives to acquire EVs are being developed, such as free or privileged parking, tolls reduction and the generalization of charging points in Portuguese cities and highways. Therefore, the number of Electric Vehicle Users (EVU) is growing. According to the International Energy Agency (2019), electric mobility is developing at a rapid pace, the global electric car fleet exceeded 5.1 million in 2018, up by two million since 2017, this notorious growth can be confirmed on figure 1, bellow:

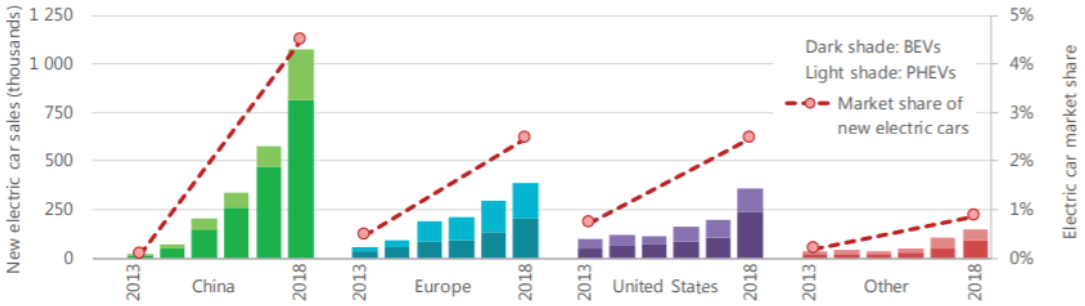

Figure 1 - Global electric car sales and market share (2013/2018)

EV sales growth represents a challenge to the electric mobility industry, the offer of electric mobility services such as charging services, do not meet the demand. Adapting to this mobility mode presents several opportunities to develop new innovative solutions. Creating charging infrastructures that ensure smart management of the needs of different types of locations is crucial.

This project focus on individual EM, this subsector has been the focal point of technological evolution and has several challenges that require the formulation and reformulation of laws and public programs, as well as the development of new business models to answer these challenges. The Portuguese electric mobility industry comprises all the integrated charging stations (CS) and remaining infrastructures, of public or private access, related to the charge of electric vehicles' batteries, whereby intervene the entities, which aim to allow the access of electric vehicle users to the EM.

Working with INESC TEC, an innovation center focused on technological and process innovation, offered the perspective of what is the electric mobility context and technology challenges.

1.2 Problem Description and Motivations

The problems of current EM services involve lack of public infraestuctures that meet customers needs. This project aims to solve is the gap between the market opportunity of creating an innovative electric mobility service at commercial buildings, where the standstill times of EVs can be made to use. Therefore, in this context, a particular case of interest would be the integration of electric mobility services on commercial buildings, such as supermarkets. The presence of parking areas and an electric infrastructure of greater dimension allows the integration of those. Hence, developing services to manage electric mobility services is considered to be an opportunity. The main advantage observed is the ability for EVs to be charged while not in use, EVUs are able to use charging stations while performing other activities.

The proposed solution shall bring efficacy of time use by EVUs, and on the other hand, the supermarket has a new valuable offer for customers, can solve problems of demand response by balancing service prices, can reach more profit by charging the service and by bringing the largest number of customers to their building. According to the supermarket goals and users' profile, the electric mobility service must satisfy the customer goals and improve rentability indexes. Further benefits were discovered as the research was being conducted and are going to be exposed later in this report.

The present study is based on Service Design (SD) concept and process, which allowed the results of the project to be designed according to what was defined at the beginning of the process. SD is an interdisciplinary, creative and holistic approach which is becoming commonly used to improve and create services. This approach considers the customer or user as the starting point for launching a new service or improve an existing one (Holmlid & Evenson, 2008). SD has a fundamental importance in service innovation because it brings innovative ideas to life (Ostrom et al., 2010). Service Innovation refers to the creation of new and/or improved service offerings, service processes, and service business models (Ostrom et al., 2010). A gap in the literature was observed, it was not found a service design method applied to electric mobility charging services for individual vehicles, which encouraged further research and the development of a Service Design model customized for this problem.

1.3 Objectives and Research Questions

This research has two main objectives. The first one is the development of an electric mobility service able to meet EVU's needs and expectations, with regard to parking and charging EVs, and grocery shopping, this expectations are going to be explored in section 5, of this report. Hence, crossing EV charging solutions inside the supermarket infrastructure, creating a complete solution of the overall system. The service is developed using service design

methodologies. So, the second main objective is the development of SD method that fits these problem specificities.

In order to achieve the two main goals of the project, there were identified and characterized the different stakeholders involved in the electric mobility network in Portugal, a customer experience research was undertaken to identify customer needs and desires, and several methods and services design tools were utilized gradually construct the solution.

Furthermore, in this sub-section, the research questions intendend to be answered in this thesis are defined. These questions conduct the research throughout the stages covered. Aiming to answer the questions, this study interviews and a workshop were performed to collect data, the data gathered was carefully analysed and solution was designed. Thereby, the research questions are:

What new opportunities emerge among electric mobility services on commercial buildings?

Discover of the gap between current service offers and customer needs, what are the existing business models and what is feasible to design the intended objetives. The aim is to find what are the possible service offers for electric mobility charging services in commercial buildings.

How can we understand the customer experience of electric mobility services?

Know what and how EVUs perform the respective activities, how they perceive them, what are their likes and dislikes, what are their expectations for an electric mobility service in a commercial building and to define consumption profiles.

How can service design method be applied and adapted to electric mobility services?

What service design methods are applied in electric mobility services and what new methods can be applied.

Besides these research objectives, the thesis also has a managerial oriented objective:

What kind of services are needed for electric vehicle charging in a supermarket?

After answering the question above, it was found an opportunity to develop a service to fill the gaps found in the research and meet stakeholder's expectations in an innovative way.

1.4 Report outline

The master thesis is structured as follows:
Section 2 presents the literature by which this research is going to be based on with the purpose of enhancing the understanding of the matters in question. This chapter reviews relevant research on the current situation of customer experience electric as well as business models for electric mobility. This section also includes a study on SD principals, processes, tools and methods. Section 3 explains the research methodology, that is, the process of how the research was performed, including the research method chosen, what is the sample studied, how the data was collected and analysed and what methods were used. Section 4 states the discussion of the findings of the data analysed, and the results of designing a new service for electric mobility. Finally, section 6 presents the main conclusions of the research.

2 Literature Review

This chapter describes the research theoretical foundation covering the relevant literature on, customer experience, Electric Mobility Network (EMN) overall and Electric Mobility (EM) business models. Additionally, it explores and defines SD concept, process, methods, and tools.

2.1 Customer Experience

This section describes the conclusions of scientific studies of the customer experience regarding electric mobility services.

Experience is defined as a takeaway of impressions that customers have when they encounter products, services, and businesses (Carbone and Haeckel, 2005). Also, experience is said to occur when a firm intentionally constructs one, in order to engage customers (Hultén, 2011). This term is gaining further interest for companies and authors, who affirm that it refers to the new economic value or the fourth offering, after commodity, good, and service, is the new engine of economic growth for organizations. (Ren, L., Qiu, H., Wang, P., & Lin, P. M. C., 2016). Furthermore, experience can be divided according to the traits of what is being experienced. Brakus et al. (2009) distinguish between product experiences, shopping, and service experiences, as well as consumption experiences, concluding that all such experiences impact directly or indirectly on consumers.

The study of experiences is a current concern that deals with intangibility and ambiguity since, any experience is highly subjective as human beings have feelings, different opinions, approaches, and manors. The offered product or service provides one set of clues, by the physical settings also employees and every resource involved. In other words, customer experience comprises every aspect of a company's offering, not only the quality of customer attention but also advertising, packaging, product or service features, ease of use and reliability (Meyer and Schwager, 2007). Each of these clues convey a message, suggesting something to the buyer, and the combination of all the clues constitute the total customer experience. (Haeckel et al., 2003). All these clues are perceived by customers in an individual way.

Authors agree with the existence of direct and strong relationships between profit, growth, customer loyalty, customer satisfaction, and service value, service quality and customer loyalty. Also, an improved customer experience may reduce churn rate and build competitive advantage (Duncan et al., 2013). Therefore, organizations able to fully manage the total experience obtain great rewards such as reduced churn rate, enriched customer satisfaction, increased revenue and reduced costs. In seeking to achieve innovative experiences,

organizations must clearly focus on customers' expectations and satisfaction, alongside with environmental factors. (Conway and Leighton, 2012).

Customer experience and customer satisfaction are related. To better understand this, the definition of customer satisfaction should be clarified, it is viewed as a post choice evaluative judgment of a specific purchase occasion. In turn, understanding the concept of service value is also important, Zeithaml (1988) defined it as "perceived quality can be defined as the consumer's judgment about a product's overall excellence or superiority". Service quality is believed to depend on gaps between delivered and desired service on certain dimensions. Hence, service quality is the perception of the service experienced, in comparison with the expected service. In addition, the concept of customer value should be considered as well, this concept can be defined as a combination of both functional and emotional benefits received without the financial and the nonfinancial components suffered.

In order to enhance and fulfill an overall customer experience, companies should pay close attention and properly manage the emotive element of experiences with the same accuracy they deploy to the functionality. Huber et al. (2001) suggest that to evaluate the perceived customer value of a product, the costs of obtaining the perceived benefits are usually the major concern of buyers, since consumers may apply principles of costs-benefits to evaluate a purchase.

Customer experience has become increasingly important for service organizations that see it as a source of sustainable competitive advantage (Teixeira et al., 2012) since it engage and retain customers generating loyalty and long-term profitable relationships. Also, is key since is the impression a consumer gets with a brand across every stage of the customer journey being crucial to a consistent and sustained growth of any business.

In order to understand customers' experience of a designated service, it is critical to work closely with them, gathering the right information of the employee journey. There are different methods to map the customer experience such as customer journeys (CJ) and customer experience modeling (CEM).

This involves mapping customer journeys and touchpoints in detail, using proprietary techniques such as the customer journey maps, this tool illustrates service experience from the customer's point of view. According to Mager (2008), the customer journey illustrates how the customer perceives and experiences the service interface along the time axis. The focus is on the customer's experience and perception of the service in each timeframe. This tool helps the service designers understanding what aspects customers enjoy and dislike, and how they do things. Also, the customer journey map focuses exclusively on the user experience, highlighting step by step all the options available to the user. The user experience can be visualized through storyboards and videos as well. (Foglieni et al., 2018)

In addition, while existing methods address some of the elements of customer experiences, there is a model that systematizes the representation of a more holistic view of the customer experience to support service design. This model is named Customer Experience Map which represents the customer experience in a way that supports service design efforts to create the service concept (Teixeira et al., 2012).

The advantages of understanding the customer experience and mapping it when creating or improving services can be a differentiation factor. Consequently, organizations who implement the desired modifications to provide customers a satisfactory service, can put themselves in a better position within the market. By designing innovative customer experiences, service providers can enhance a pleasing experience, especially if these innovative experiences are provided before competitors do, enhancing the probabilities of obtaining new customers, customer loyalty and higher profits.

2.2 Business Models for Electric Mobility

This section establishes the essential findings of the literature review on electric mobility business models. Several studies provide a broad discussion of the business model for the provision of charging infrastructure. For a better understanding of Electric Mobility (EM), and charging infrastructures, an overview of this topic was undertaken, this information is available in Appendix H. For the purpose of clarity in discussing charging companies and their associated networks, we define here four primary functions in this value chain. Entso (2019) characterized the Electric Vehicle (EV) charging infrastructure value chain is by four main functions: manufacturing, development and installation, network operation, and sales and marketing. Business models for charging services vary widely and may serve one, some, or all four functions:

1. Manufacturing: the original equipment manufacturer who produces charging equipment such as mounted home chargers and standalone public Charging Stations (CS);
2. Installation/Development: arranges and executes installation and sources financing;
3. Network Operation: manages and provides maintenance and customer-facing services for the physical network and payment platform;
4. Sales and Marketing: the entity that hosts infrastructure, sets payment structure and prices, and/or collects or shares revenues from resale of electricity.

A common business model is the contracting models for CSs, where retailers do not install those due to lack of instant revenues, the construction of charging stations solely for marketing purposes appears unattractive to many energy providers (Laurischkat et al. 2016). Thus, it has already been implemented, the energy provider supplies, installs and maintains the charging station for his customer. In return, the customer pays a fixed monthly rate to his energy provider. The customer avoids high acquisition costs and the provider profits from continuous revenues. Garas et al., (2016), also labeled two business model approaches: a) network-operator model occurs when a company develops and maintains a network, but sells the actual hardware to host sites, which then manage billing and access to charging stations. b) owner-operator model is a vertically integrated set of functions in which the charging company supplies and owns hardware, manages billing and access, and collects revenues from the infrastructure. The owner-operator model is like a traditional telecommunications company that invests in infrastructure and charges clients for the services provided by the infrastructure.

For EM, the main business models found are described in detail:

- E-Car-Sharing: E-car-sharing contains an electric vehicle fleet that is offered to a closed user-group in a defined business area (Laurischkat etal. 2016). Private car ownership in the context of the ongoing urbanization is creating challenges, such as high energy costs, and limited and expensive parking (Degirmenci, 2014). In Portugal, *DriveNow* in Lisboa is an example of this business model.
- Intermodal Transport: Intermodal transport is a combination of individual and collective transport. The customer makes use of different electric transportation modes and services to manage the distance (Laurischkat et al. 2016). In practice, an intermodal mobility provider bundles the transportation offerings from other providers on one platform and runs the central billing. In Portugal, *Park&Ride* is an example of this business model.
- Vehicle-to-Grid (V2G): In the V2G business model pattern the standstill times of EVs and the ultimately capacity of the integrated transaction batteries are used in return for the payment of a fee (Weiller and Neely, 2014). In this model, batteries can be discharged to provide energy. In Portugal, EDP Commercial is testing a new V2G business model charger for EVs.
- Battery Swapping: At battery replacement stations, empty batteries can be swapped with charged ones. Thanks to photovoltaic systems, the energy can be provided in the same place it is produced in replacement stations either private, semi-public or public space. (Esmaeili et al. 2019) The process of battery swapping is very short and much faster than fast charging. Tesla already has a battery pilot program da tesla for the S Model.
- E-Roaming: Due to the business model pattern e-roaming, charging infrastructure providers are connected to a roaming platform. Kumar (2017) defines roaming as the mechanism enabling the possibility of offering the same or similar service to a roaming user in a visited network. For instance, through *ChargeNow*, BMW has access to *Mobi.e's* network of charging.

Weiller (2014) affirms that while residential applications such as vehicle-to-home and smart home systems are realisable soon, grid-scale uses of EV batteries for generation, storage or for V2G will only be deployed in the long term.

In Portugal, is important to understand what entities are responsible for EM activities and who is involved. According to the Portuguese Energy Services Regulatory Authority (ERSE), currently, the key entities involved in the EM sector are the Ministry of Economy, ERSE, the General Directorate for Energy and Geology (DGEG), the Managing Entity of the EMN, Suppliers of electricity, Authorization Holders of Electric Mobility Commercialization (EMC), Operators of the Charging Stations (OPC) and UVEs. On Appendix G there is a list of EM entities and respective description.

In order to develop an EM service, regulations and governance in force, in Portugal, must be studied and followed. The regulations are made by the ministry of economy, ERSE, and the General Directorate for Energy and Geology. The main EM activities are: a) The commercialization of electricity for EM; b) The operation of CSs of the Electric Mobility

Network (EMN); and c) The management of operation of the EMN. The performance of the first activity mentioned above is currently carried out through a free competition system. Other activities associated or complementary to the main activities, such as the provision of parking spaces for electric vehicles and its location, are performed through a free competition system as well. The Electric Mobility Comercialization entities shall provide information and cooperation with *Mobi*.e, which is the managing entity of the EMN, aiming to fulfill the obligations regarding the management and monitoring of energy and financial flows, in order to guarantee information of consumptions and prices prevailed on each moment. The OPC is obligated to integrate the systems and CSs explored by that entity, in the EMN, managed by *Mobi*.e. that ensures the conditions for the legal relationships for the end-users to access those CSs. The operators of the CS must provide information to *Mobi*.e to make the monitoring possible.

Mobility as a service (MaaS) stands for buying mobility services based on consumers' needs instead of buying the means of transport. Through MaaS systems, consumers can purchase services, through integrated platforms. The platform provides different transport modes and information services such as car-sharing, car rental, underground rail, bus, bike-sharing, booking systems, and real-time information about consumptions, CSs, Transports, prices, etc. (UCL Energy Institute, 2015). When considering the technology-enabled aspects, one important point to indicate is that in Portugal, EVUss can access CSs in two ways:

- A card provided by a designated EMC with Radio Frequency Identification Technology (RFID) to access CSs that identify the user of the EMN, discloses CSs and associates the charges to the current agreement.
- Through an Application Programming Interface (API) or via other electronic methods, which may be provided by a EMC, and allow, between other functionalities, the identification and authentication of the associated electric vehicle users, the visualization of the disposable CSs, the selection of use of those points, as well as leading off ending charging times remotely.

The card and the other ways to access the CSs of the EMN are of the exclusive property of the EMC. The payment of the services provided by an OPC, and its direct or indirect cost charged to an UVE, must be equal regardless of EMC hired by the UVE. The price and commercialization conditions information, such as tariffs and taxes, to access CSs must be provided to the UVEs by the OPC, this information shall bell visible at each CS, and it should be disposed of in other ways, such as an API interface or other electronic methods.

Considering electric mobility business models in commercial buildings, the park and charge business model constitutes a complementing business model for customers who already have an electric vehicle. Consequently, the overall success of this business model depends on the licensed electric vehicles. For instance, providers of the park and charge business models address customers from shopping centres who get get additional incentives to visit the shops (Laurischkat et al., 2016).

Based on this review, it is possible to conclude that technology-enabled ‘new mobility’ solutions to meet diverse transportation, charging and information needs. However, EM has

not yet reached a level of technological maturity (Chan, 2007). Besides, no clear business model has yet emerged for the provision of charging infrastructure, these models may vary between the combinations of manufacturing, development and installation, network operation, and sales and marketing. Few studies evaluate existing models od EV charging for individual transportation in detail, so novel business models and services have to evolve and meet the needs of EM charging services for individual transportation. Therefore, no business model in specific was undertaken. The proposed solution was developed using a Service Design process.

2.3 Service design

The services intangibility and the need for differentiation, make the services market very competitive and highly unpredictable. In order to do so, Blomkvist et al. (2010), refer to Service Design as a human-centered, holistic, creative approach. This approach allows service design to orchestrate service elements such as the physical environment, people (customers and employees), and service delivery process to help customers co-create their desired experiences (Teixeira et al. 2012). Hence, SD focuses on delivering customer value, it helps to understand customers, the market, resources, and insights into the client's expectations and experiences across all interfaces and over time (Gibbons, 2017).

On SD perspective, services need to be methodically developed, SD is the activity of planning and organizing a business's resources (people, props, and processes) in order to (1) directly improve the employee's experience, and (2) indirectly, the customer's experience (Gibbons, 2017). Edvardsson et al. (2000) consider three main components of service design: the service concept, the service system, and the service process. More recently, Patrício at al. (2011) integrated these three layers into a service design approach creating a set of interrelated models, each one addressing a different layer (Patrício et al, 2011).

Furthermore, when designing these systems, thinking with models helps bridge the gap between problem and solution (Dubberly et al. 2008). SD provides methods and tools for orchestrating and materializing interactions between people, institutions, and technological systems in innovative ways (Teixeira et al., 2017).

Service Design Principles

Stickdorn and Schneider (2010), established has five key SD principles: user-centered, co-creative, sequencing, evidencing and holistic. Although, the principles did not represent the entire SD concept. In accordance with Stickdorn, Hormess, and Lawrence (2017), the new principles of service design are:

- Human-centered: Requires users and stakeholders' participation;
- Collaborative: Integration of multidisciplinary teams;

- Iterative: SD process is composed of iterative stages of understanding the customer, designing the service offering and prototyping the experience;
- Sequential: Meaning that service actions are all interrelated through a sequence;
- Real: The process must occur in a real context, researching and prototyping feasible ideas, turning intangible into tangible.
- Holistic: Functions with every aspect of the system, addressing the needs of the users and stakeholders.

Service Design Process

The service design process has been widely represented by the academic and professional fields, commonly structured from three to more steps. After analyzing the literature, authors share the opinion that service design begins with exploration and research and finishes with a final step of delivery of the solution to be implemented (Foglieni, Villari and Maffei, 2018). SD processes differ according to the context and objectives of the service, although it is possible to see that there are certain similarities between the frameworks.

Moritz (2005) groups the Service Design process into six categories: 1) understanding (learning about clients, context, the service provides and providing insights), 2) thinking (giving strategic direction that facilitate the process direction), 3) generating (development of concepts and creation of solutions), 4) filtering (selection of the most suitable concepts and solutions), 5) explaining (provision of visual and tangible tools through understanding, visualisation and mapping), 6) realizing (implementation and delivery). In turn, the Design Council (2013), developed the "Double Diamond" model that divided the service design process into four distinct stages: 1) discover (discovery, gathering inspiration and insights, identifying user needs and developing initial ideas), 2) define (make sense of all the possibilities identified in the discovering phase), 3) develop (solutions are created, prototyped, tested and iterated), and 4) deliver (the resulting product or service is finalized and launched). In addition, Mager (2009) also introduce an implementation phase where the IT process, development and training take place.

Patrício and Fisk (2013) structured the SD process in 4 stages (see figure 2):

Figura 2 - Service Design Process

1. Exploration: Study of stakeholders, the project, the context, together with their experience, behavior, and environment in a human-centered design approach.
2. Ideation: Generation and development of new ideas that might lead to service solutions. At this stage, it is crucial to include all the main stakeholders and to work with multidisciplinary teams.

3. Reflection: Prototype the developed service concepts followed by a test of it with potential users.
4. Implementation: Planning, implementing and monitoring the necessary modifications to put the new service concept accessible to the customers

The service design process has therefore common important factors when applying service design processes involve understanding the service users, the environment and applicable technologies, studying and profiling, as well as participating with the users and creating visual tools during the process, plus generating ideas, prototyping, evaluating them, in order to iterate and improve for better solutions. Concluding, SD process has evolved, and the last process presented, based on 1) exploration, 2) ideation, 3) reflection, and 4) implementation, is the process guide used in this thesis.

Service Design Techniques and Tools

Service Design connects the techniques, methods, and tools from the various fields, such as information technology and marketing, to employ them in the specific development of services. The use of tools may vary per project depending on the nature of the project, its context, the business, and those tools that could be used several times in the process and its iterations. Methods and tools are used to make the service experience consistent, desirable, useful, and viable, in line with the brand and commercially successful (Moritz 2005). Techniques and tools are very important, the transition from understanding the customer experience to devising service solutions is crucial for service design, and models can play a key role in facilitating this transition process (Patrício and Fisk, 2013).

Different tools serve the purpose of different Service Design stages:

Exploration tools, that must allow the understanding of the context, the end-users and the organization's perspective. According to Moritz (2005), service designers may include Benchmarking, Client segmentation, Context analysis, Contextual interviews, Contextual inquiry, Critical incident technique, Ecology map, Ethnography Experience test, Expert interviews, Focus groups, Interviews, Market segmentation, Mind Mapping, Observation, Trend Scouting, User Surveys, 5W’s Insight. Furthermore, Benchmarking, as an exploratory technique, enables the research, comparison, and discovery of other businesses, services.

The Stakeholder Map, in accordance with the Interaction Design Foundation (2018), allows the determination of who the stakeholders are and how much attention and effort each stakeholder should be given. The Context Map reveals the user’s conscious and latent needs, experiences, hopes, and expectations (Miettinen, 2009).

Personas are a generalized characterization of a user created, through a series of user research and studies, to symbolize a group. This tool highlights users' perspectives through its subjective view, it represents an aggregated conceptual model of targeted user groups used to support collective knowledge that strengthens user-centered design through analysis, design, development and implementation process. (Lerouge et al., 2011).

Furthermore, the Customer Journey map is a tool that illustrates service experience from the customer's point of view. According to Mager (2008), the customer journey illustrates how the customer perceives and experiences the service interface along the time axis. In addition, CEM systematizes information from customers in a way that supports the service concept conception (Teixeira et al., 2012).

In the Ideation phase, the concept must be designed so, techniques and tools should be used to enable the creation of ideas. For this purpose, designers can make use of interviews, focus groups, workshop and brainstorming (Moritz, 2005). At this stage of the process, the objectives also require defining the concepts through tools such as affinity diagrams, fishbone diagram, lateral thinking, LEGO serious play and Mindmap (Moritz, 2005). The next objective is to filter those ideas to come up with the result through tools such as card sorting, cognitive walkthrough, expert evaluation, a feasibility check, focus groups, personas, PEST analysis, sticker vote, SWOT analysis, task analysis (Moritz, 2005).

Norman and Ramirez (1993) developed the value constellation, which represents the network of actors and their relationships that jointly create an offering. The Customer Value Constellation represents the set of service offerings and respective interrelationships that enable customers to co-create their value constellation experience for given customer activity. Furthermore, according to Patrício (2011), the design of the service system, in the multilevel service system, is accomplished through the Service System Architecture (SSA) and the Service System Navigation (SSN). The SSA defines the structure of the service system, providing an integrated view of the multi-interface offering and support processes across the different tasks of the service experience. The SSN is a tool that establishes the set of customer activities and how they are supported by different service interfaces (Patrício et al. 2011).

At the reflexion phase the testing and prototyping the concept is the focus. Developed experience prototyping is a method for creating, generating and modeling new service features. Experience prototype is the representation of a design, made before the final solution exists. According to the Design Council (2018), experience prototypes should result in several physical mock-ups of touchpoints, several interactions recreated in some way or a combination of both. Furthermore, the prototyping can draw on storyboards which illustrate the newly created service process from the perspective of the clients and helps to visualize the full observation of scripts, roles, and scenery. Mockups can clarify where design interventions are possible in service provision (Mager, 2008).

Service Design Methods

In this section, some Service Design methods are explained. The development of new service design methods has been useful to the SD process adaptation according to the context and objectives of the service.

Multilevel Service Design

Multilevel Service Design (MSD) developed by Patrício et al. (2011), constitutes a multi-disciplinary method for the integrative design of service systems. This method recognizes that

organizations cannot design customer experiences, but service systems can be designed for the customer experience, hence this model purposes the methodological design of the service. According to Patrício (2017), MSD method enables the integrated design of service offerings at three hierarchical levels with a strong focus on the customer experience. This method is organized into 3 levels of design: Designing the service concept; Designing the service system; and Designing each service encounter. MSD process is composed of four steps:

1. Studying the Customer Experience aims to understand the customer experience, using qualitative methods. This phase is concerned with studying the customer in three levels of experience: the value constellation experience, the service experience, and the service encounter experience.
2. In Multilevel Service Design the definition of service concept is the firm's positioning in the customer value constellation including the services offered and the links and partnerships established with other organizations in the network to enhance the firm's value proposition.
3. Design of the firm's Service System is achieved through the service system architecture and service system navigation. The first one describes the structure of the service system, giving an integrated view of the multi-interface offering and support processes across the service experience. The Service System Navigation illustrates the alternative paths customers can take across different service encounters in the service experience.
4. According to Patricio et al. (2008), the design of the Service Encounter is represented by the service experience blueprint. Service encounters are defined as the moments of interaction, between the customer and the service provider.

MINDS Method

The MINDS method (Management and INteraction Design for Service), developed by Teixeira et al. (2017), followed Design Science Research, a methodology born in the information technology field. Using this methodology, the MINDS method integrates management and interaction design approaches to support designing technology-enabled services. Using the MSD model, the MINDS process is organized in three service design levels (service concept, service system, and service encounter).

After analysing the MINDS method, the study of Product-Service System was undertaken:

Product-Service System

According to Wong (2004) Product-Service-Systems (PSS) may be defined as a solution offered for sale that involves both a product and a service element, to deliver the required functionality. PSS provides significant support for the development and implementation of product-service system solutions from an organizational perspective that it focuses on

product-centric solutions. In accordance with Baines et al. (2007), PSS are integrated product and service offerings that deliver value in use, achieving differentiation that way.

PSS approaches provide tools and methods that help to visualize systemic and network components such as contextual actor-network map, stakeholder's motivation matrix, and stakeholder's system map. In contrast, it uses models that also focus on visualizing contextual components from a more local perspective such as contextual design analysis, flow model, artifact model, and physical model. According to Costa et al. (2017), these methods support the development of integrated solutions that are based on partnerships among organizational networks, thus facilitating the implementation.

To conclude, the methods developed for different purposes, services, contexts. With distinctive traits, integrating different fields, utilizing different techniques and tools. Overall, SD methods aim unique solutions, inside the objective of developing new services or improving existing ones.

SD enables the development of ideal human interactions, through examining the customer experience, determining pain points and moments of delight. This also enables co-creation and the consideration of everyone involved not only customers, but companies and the overall context participants. Having method and methodical thinking is crucial to develop a service, iteration within phases is also important. As a core pillar of design, creating consistency in a service is about making it intuitive. By examining all the levels of a service, desirable outcomes of the different aspects that service can be designed. SD embraces change, it can help the obtention higher adoption and retention rates, as well as increase customer satisfaction. SD holistic view fosters creativity and collaboration. It's a fresh perspective, incorporating various angles into a solution that include the client, customer, stakeholders and even external factors such as the environment.

After the analysis of the literature, it was concluded that customer experience is crucial when impoving and developing new services, and it can be a competititve advantage, therefore customer experience modelling and customer journey will be utilized to develop the service proposed. In adittion, considering electric mobility charging services for individual vehicles in commercial buildings, such as supermarkets, there is no literature and business model applied. Therefore, no business model in specific was undertaken in this project. The proposed solution was developed using a Service Design process, the process undertaken is divided in three stages: 1) Exploration, 2) Ideation and 3) Reflexion. Since no service design model was ever applied to electric mobility services, a group of service design tecniques and tools where adopted to the designing process.

3 Methodology

In order to achieve the expected results, this study was conducted using the Service Design (SD) process supported on Design Science Research methodology. At the beginning of the research, to obtain the intended data for the development of the service, a qualitative research was conducted based on semi-structured interviews with several stakeholders.

3.1 Design Science Research

Theoretical foundations on designing research have been analyzed, the information consolidated highlights some approaches. The most suitable to serve the purpose of this thesis was Design Science Research (DSR), following the process created by Peffers et. al. in 2007. In accordance with to Weber et al. (2018), DSR is the type of research where researches focus on building artefacts, they believe will be useful to a stakeholder community. According to Hevner et. al. (2004), DSR methodology addresses unsolved problems through unique and innovative techniques and solves a class of problem in an effective or efficient manner. The objective of this project is the creation of artifacts. The authors group 3 types of IT artifacts that consist of constructs (vocabulary and symbols), models (abstractions and representations), methods (algorithms and practices), and instantiations (implemented and prototype systems). Therefore, the result of design science research is a purposeful artifact created to address an organizational problem. This artifact should be properly described so that its implementation can be possible. This thesis is based on the construct of a method, in terms of the process pursued and how was the application developed and the instantiation, which is the application of the method itself.

Peffers et al. (2007) stated that design science research process should approach the following activities:

> Activity 1. Identify problem and motivation: This implies the definition of the research problem and justification of the value of a solution. The problem definition will be used to develop an artifact that can effectively provide a solution. Justifying the value of the solution accomplishes two things: it motivates the researcher and the audience of the research to pursue the solution and to accept the results. Also, it helps to understand the reasoning associated with the researcher's understanding of the problem.

The problem and motivation that trigger the value of the solution were exposed in the section 1, electric vehicle sales growth represents a challenge to the electric mobility industry, the offer does not meet demand. In this context, an interesting case, is the the development of a electric vehicle charging service for commercial buildings. Therefore, after defining the problem and pointing the value of its solution there should be determined the performance objectives for a solution. In other words, how should the problem be solved and what are the standards that the solution must achieve.

> Activity 2. Define objectives of a solution: Infer the objectives of a solution from the problem definition and knowledge of what is possible and feasible. The objectives should be inferred rationally from the problem specification.

The problem that this project aims to solve is the gap between the market opportunity of creating a new service for electric vehicle charging within commercial context where standstill times are not used effciantly. At the same time, a gap in the literature revealed that there was no SD method to applied in this industry's services. So, the second main goal of this thesis is the application of a service design approaches within the context of electric mobility, to design a new solution.

In design science research, designing and developing can be taken as an iterative search In order to develop artifacts, according to Grenha et al. (2016), models and methods must follow appropriate theoretical foundations and research methodologies to ensure that these artifacts address the identified challenges and research is rigorously pursued.

The following activity is the creation of the artifact that solves the problem defined.

> *Activity 3.* Design and develop: Create an artifactual solution. Such artifacts are potential, with each defined broadly, constructs, models, methods, or instantiations. This activity includes determining the artifact’s desired functionality and its architecture and then creating the actual artifact

The Service Design process proposed to develop a new electric charging service is presented in section 3.3 of this report.

After the design of the solution, a demonstration of its effectiveness should be performed:

> *Activity 4*. Application: Apply the efficacy of the artifact to solve the problem. This could involve its use in experimentation, simulation, a case study, proof, or other appropriate activity.

The application proves the artifact works, by solving one or more instances of the problem. The application of the artifact was undertaken, showing how the method developed was able to support the design of the service during a workshop section of co-creation, with four electric vehicle users, and potential customers, this proved the validation of the service concept. Furthermore, the project instantiation was not applied due to the last stage of SD (implementation) needs, besides users' involvement, a service provider involvement, so the validation of the service system is not accomplished, causing the non-viability of the implementation of the service.

> *Activity 5*. Evaluate: Observe and measure how well the artifact supports a solution to the problem. This activity involves comparing the objectives of a solution to actual observed results from the use of the artifact in the demonstration.

The evaluation stage measures how well the artifact works, meaning that is observed and measured the degree of adherence the artifact has with the proposed solution on section 1, comparing objectives with results. Peffers K. et al (2007) claim that this process finishes when the performed work is communicated:

> *Activity 6.* Communication: Communicate the problem and its importance, the artifact, its utility and novelty, the rigor of its design, and its effectiveness to researchers and other relevant audiences, such as practicing professionals, when appropriate.

The proposal of future works by which the method designed can be applied and studied is mentioned in section 6.

3.2 Qualitative Research

Qualitative research was undertaken, to support the understanding of the customers' experience, on the exploration stage of SD process. DSR methodology was followed in this research, Neuman (2000) distinguishes two categories for data collection, quantitative data collection provides data in the form of numbers and qualitative provides data in the form of words and pictures. According to Hevner et al. (2004), qualitative research can be used as part of the overall DSR to explore and understand the context and evaluate artifacts, this makes qualitative research suitable especially at the beginning of the research process, because it allows discovering the meaning of how people make sense of different themes and experiences. In accordance with Neuman (2014), qualitative research is suitable to acquire an in-depth understanding of a subject, in other words, it provides information detailing the reasons and motivations in the form of words and pictures. Therefore, this exploratory research aims to increase knowledge about the research problem, define the focus and priorities of the study and understand the behaviors and attitudes of the people involved.

3.3 Design and Develop

Theoretical foundations presented on section 2.3 supported the integration of complementary contributions from different service design approaches. Since a gap in the literature was found, this project does not follow a specific SD Method, instead, it was gathered some approaches of different SD methods that best suited this case, consequently a new service design method was developed. This method follows Patrício and Fisk (2013) structured SD process of four stages, presented in figure 3.

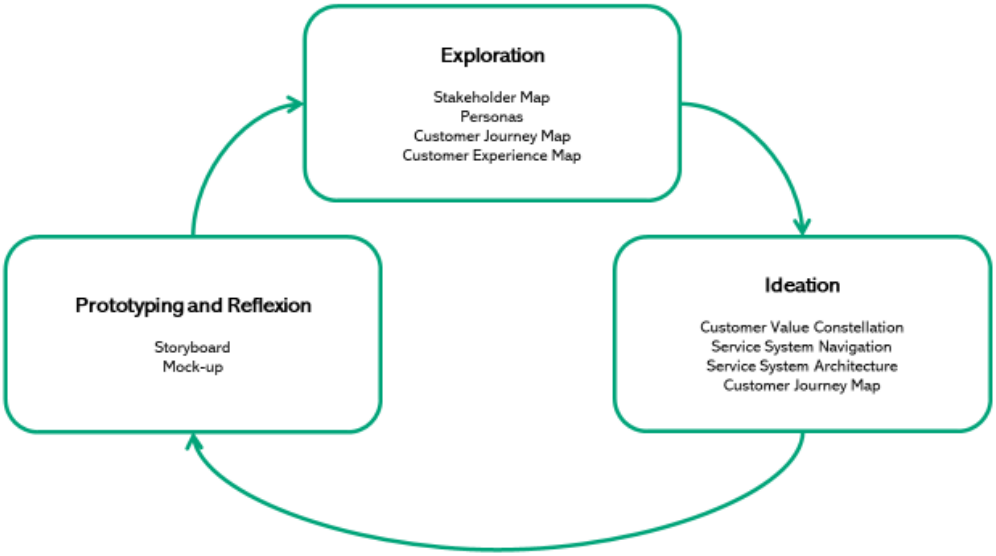

Figura 3 - Proposed Service Design process

Exploration

In the exploration stage, a study of the customer experience was undertaken. Existing service design methods focus on separating elements of the customer experience, although the design must cover the holistic nature of customer experience and take any and all elements and touchpoints into account (Berry et al., 2002). The design tools used to explore and understand people involved in the service context were Stakeholder Map and Personas. Next, to finish mapping the customer experience it was used CEM in accordance with Teixeira el.al. (2012). CEM supports the holistic nature of customer experience, provides a picture of the experience context, and considers the physical artifacts, the technology-enabled systems, and the actors involved in each activity throughout a customer journey, therefore Customer Journey Maps and Experience Maps are utilized.

3.3.1 Sample Design

In the exploration stage, to pursue the customer experience study. In accordance with Marshall (1996), three kinds of approaches for selecting a sample for a qualitative study exist. The convenience sample focuses on the selection of the most accessible subjects. The theoretical sample is defined as the research evolves, it adapts itself from the emerging data, new samples can be elaborated through the process. The judgment sample is based on the researcher's choice of the sample and for that reason, the researcher must have knowledge about the research area.

The desired sample was created considering the goals of this project and, during the interview execution, this pre-defined sample was considered to have a higher number of electric vehicle users. However, due to constraints related to the lack of contacts with customers, the initial sample was not entirely applied. Hence, to define the sample design for this research, it would be important to find Electric Vehicle Users, driving either Pure Electric Vehicles (PEV) or Plug in Hybrid Electric Vehicles (PHEV). Demographically, it was preferable to sample people from a wide age range, from both genders, and different locations of Portugal. Going grocery shopping was not a requirement since the objective was to discover if that extra service could influence new customers. Therefore, a convenience sample was selected based on the requirements mentioned above and people's availability. The sample was composed of 19 individuals (see table 1). Considering the type of EV the sample drove, seven people owned an PHEV and twelve drove a PEV (see table 2).

Table 1 - Sample demographics

AGE	MALE	FEMALE	TOTAL
20-30	3	3	6
31-40	3	2	5
41-50	2	2	4
51-60	3	1	4
TOTAL	11	8	19

Table 2 - Sample type of vehicle

TYPE OF VEHICLE	TOTAL
PEV	12
PHEV	7
TOTAL	19

3.3.2 Data collection

To collect qualitative data from the chosen sample was the semi-structured interview. Interviews can provide important insights about certain phenomena being studied and provide the prior history of the situation, thus helping to identify other relevant sources of evidence (Yin, 2009). The semi-structured interview enables the use of open questions, request more details for a topic, ask about feelings and thoughts, validate perspectives and use observational skills for the discussion (Charmaz, 2006). The data collection stage is a deal-breaker and defines the next stages of the service designing process. The co-creation of value with the user is the most valuable way to get real and useful information for a research (Teixeira et al., 2012).

The interviews were conducted in-person, via skype or phone call, according to the participants' availability, all the interviews performed in person occurred in a stakeholders' comfort place. During these conversations, notes were taken for later data analysis purposes, and the interviews were recorded after participants' authorization, an informed consent was signed (see Appendix A). This experience had a considerable impact on the design of the service. The purpose of the interviews in the present study was to get an in-depth

understanding of who are EVUs, what are their frustrations and desires, what challenges they face, what has their routine, in what situations they charged their vehicle, and what are their expectations with regard with electric mobility services. Hence, studying the customer experience. Two sets of interviews were performed, both scripts are presented in Appendix B and Appendix C of the thesis.

The first set was conducted with nineteen interviews one with element of sample, the interviews took from 12 to 18 minutes each. The initial group of questions of the interview guideline are direct and closed, this group considers demographic aspects, such as age, EV type and EV brand and model. Thereafter, the questions are open, open questions allow the participant to extend the topic and to explore deeper details that can be relevant for the research (Charmaz, 2006). The focus is on understanding the current use of customers' routine considering EV driving and, charging services, location, duration, and frequency, as well as problems and inconveniences of use and aspects of value. In case of need, some specific questions were performed to obtain a deeper understanding of how users act, for instance, if they owned an e-mobility card or software to manage EV charging. The third set of questions is related to participants' expectations, feelings, and preferences. The final point of this group considered if an electric mobility service on supermarkets buildings would help clients' acquisition and if so, what could be impacting value offers. The second interview was conducted in the same condition as the previous with 10 individuals, from the same sample to collaborate with the study, thus the interviews' duration is minor, taking from 5 to 10 minutes each. This was performed to get in-depth knowledge of the user experience, in specific, what activities are performed since the idea of charging their vehicle until they finish the charging experience, as well as an understanding of their grocery shopping process. This interview focuses not only on customers' activities but on their feelings and expectations. The first set of questions of the interview focus on the EV driving experience step by step, and feelings considering the approached theme. The second part of the interview is composed of the same questions approaching the grocery shopping experience.

3.3.3 Data analysis

Coding is the fundamental analytic process used by the researcher. According to Strauss and Corbin, (1990), there are three basic types of coding: open, axial, and selective. Open coding is the interpretation of data breaking it down analytically. Its main goal is finding new insights by breaking through standard ways of thinking about or interpreting phenomena reflected in the data. In axial coding, categories are related to their subcategories, and that relationships are tested. In addition, a deeper development of categories is done in order to find more indications of them. Selective coding is the process by which all categories are defined around a "core" category, and categories that need deeper explanation are filled with descriptive detail. This type of coding is commonly used in the later stages of a study. Open coding was the approach selected for the data analysis. In order to simplify this process, a computer-assisted qualitative data analysis software (CAQDAS) QRS was utilized. The software selected was Nvivo 12, able to import, manage and analyze content. All interviews were transcribed manually.

Ideation

In the ideation phase, a co-creation workshop was hosted at the ideation stage of the design process and involved service EVU. The meeting was documented through personal notes, to further analyse and consolidate results. Four participants gathered at a friendly atmosphere and jointly explored and articulated their needs and explored possible solutions. The key benefit of this co-creation approach is that it supported the validation of findings of the previous stage and enabled the identification of ways in which users would like to solve the current problems. The workshop initiated with the description and presentation of the problem and motivation, and the customer journeys and touchpoints. The next phase constituted the pain points agreement and generation of innovative ideas to solve them.

In the Ideation phase, it was designed MSD's Customer Value Constellation (CVC) from (Patricio et al. 2011) to support the design of the service concept, which includes the services offered and the links and partnerships established with other organizations in the network to enhance the service value proposition. To complement the results of this stage, also consulting Patrício et al. (2011), the SSA and the SSN was designed to depict a dynamic representation of the paths available for the customer through the channels of the service system. Thus, the consolidation of ideas happened through the design firm's service system that enables customers to follow multiple patterns of navigation across service.

Reflection

In the reflection stage, prototyping was the focus. In accordance with Teixeira et al. (2017) service design tools at the service encounter level are focused on depicting the aesthetics and interactions of service interfaces. Also, MINDS models at the service encounter level acted as initial low-fidelity prototypes. Although this project doesn't design at the service encounter level, through service blueprinting, for instance, it makes use of prototyping to do initial user and/or firms testing. However, it predominately aims to prototype service concepts, enabling the visualization of the service system, in other words, pictures the ideas generated in the previous stage of the process, through storyboards and mockups.

The implementation phase is not part of the service method developed. This method focuses on the initial stages of the SD. Further companies or service providers insights shall be given in order to complete its implementation.

On table 3, the summarized information of the project's design process is described in detail, for each stage of the process, designated activities were done to meet their respective goals, each activity was perfomed with a specific sample and then a SD model was able to be designed, creating the proposed solution of the project:

Table 3 - Method framework

Stage	Activities	Objectives	Sample	Model
Exploration	Semi-structured interviews	Define consumer profiles, and understanding the customer experience	19 EVU from Portugal	Personas Stakeholder Map Benchmarking Customer Journeys Customer experience Map
	Semi-structured interview	Deeper understanding of the customer experience (step-by-step)	10 EVU from Portugal (same EVU from 1st interview)	
Ideation	Co-creation Workshop session	Consolidate results obtained on the exploration phase. Generate ideas. Co-create new service concepts.	4 EVU from Portugal (same EVU from 1st interview)	Customer value constellation Service System Architecture Service System Navigation New Customer Journeys
Testing and Reflexion	2 mock-ups design and 1 storyboard	Prototype service concepts; Enable a clear visualization of the service system.	Not applicable	Storyboards Mock-ups

3.4 Application

The application of the problem is focused on solving its instantiations. In the exploration stage we developed the sample design, interviews were perfomed to collect qualitative data, the data gathered was later analyzed. In the ideation process a workshop session was conducted to collect more data from potential customer and that was also analyzed after the meeting. The application of the project is decribed in detail on section 4 of this report.

4 Results

In this section we present and explore the main findings obtained during the interviews' analysis and coding. We begin by crossing the main categories that will frame this research, then the stakeholder map and definition of personas based on the information analysed. Next, we performed the design of the customer experience and the service system, finishing with storyboards and mock-ups of the proposed result.

4.1 Results of the Exploration Stage

Using Nvivo, to analyse the data collected, the definition of categories was based on the research goals, the knowledge about the research obtained through the transcriptions and the structure of the interview scripts, already organized by goal. Therefore, the meta category was defined per type of user, with different traits and habits, for instance, This users in figure 4 are defined as: Stressed (Pure Electric Vehicle user with no home charge); Regular (Pure Electric Vehicle user with home charge) and Hybrids (Hybrid users). Furthermore, the main categories for the experience of electric mobility charging services were defined as: Charging Habits, Charging Traits, Charging at Commercial Buildings, Current Problems and Inconveniences, Currents Aspects of value and Service expectations.

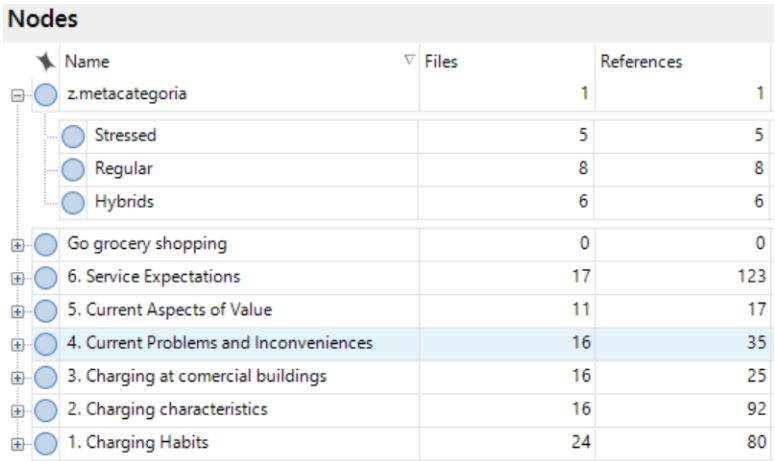

Figure 4 - Nvivo Tree (Electric Vehicle Charging Experience)

After the definition of categories and concepts, this analysis adapted axial coding. This is the execution of relating the codes (categories and subcategories) to each other, creating a hierarchy (Charmaz, 2006), this was a very iterative process in order to construct a data in a tree form, organized in the most consistent, logical and coherent way possible. Accordingly, for the electric mobility services, the categories and subcategories, represented in the software in the form of nodes and sub-nodes are represented in figure 5. In turn, the category Charging Habits is organized by charging location class - Home, Job Installations, Public Spaces, and Commercial Buildings - since the activities performed by Electric Vehicle drivers on Electric Vehicle charging differed by location. For instance, inside commercial Buildings, the classes defined are: When (weekends, evening, late afternoon, afternoon and morning), Where

(Commercial building of charging), What (activity to be performed, such as going grocery shopping or going to the movies), Activities (such as checking battery levels, deciding where to charge and finfing charging stations) and Feelings (per activity users can feel happy, nervous or hesitant, for instance). Regarding the category of going grocery shopping, the main categories were defined following a sequential order of the customer performed activities, thus each activity was a category - creating a visual analysis of the sequence of activities: 1. Need to go shopping, 2. Drive to supermarket, 3. Park vehicle, 4. Pick groceries, 5. Pay, 6. Carry bags, 7. Leave, 8. Arrive home, 9. End. The going grocery shopping node is categorized using subcategories that explain the related user feelings for each category that is each activity taken when going grocery shopping. Some categories required further analysis and in addition to feelings, the subcategory details were defined.

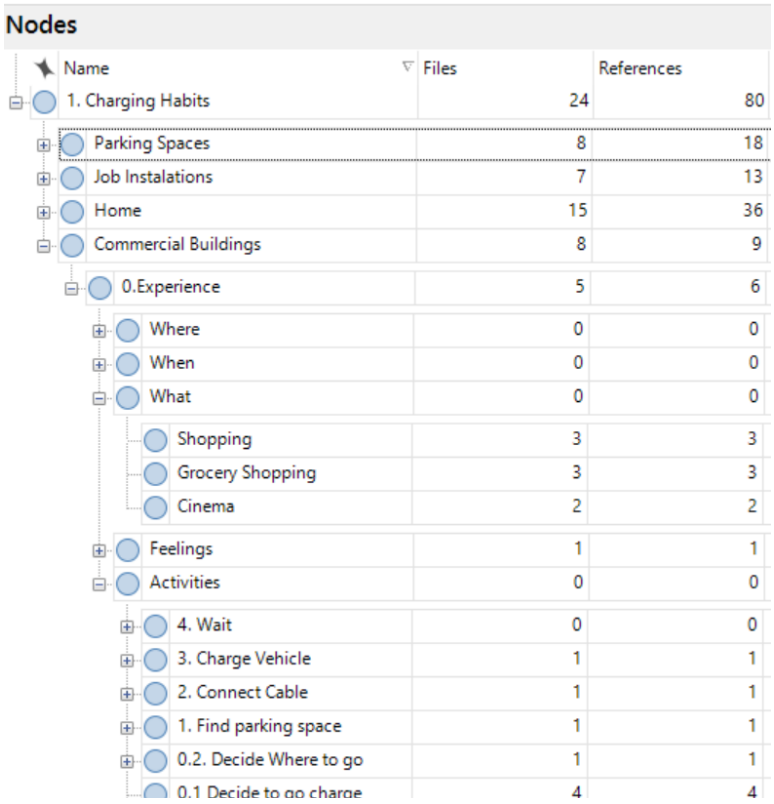

Figure 5 - Nvivo Tree categories and subcategories (Electric Vehicle Charging Experience)

Concluding, for each category, subcategories are defined to obtain a deep understanding of customers, for instance, for the Problems and Inconveniences node, the sub-nodes are its explanation - Availability, High process, Malfunctions, No client support, Slow charging and nothing, availability, in turn, was subcategorized as TVDE occupation.

Considering the current Electric Vehicle Users's (EVU) experience, it was found that the meta-category is the type of vehicle participants drove. It was also found that the difference between hybrid (PHEV) users and pure electric vehicles' (PEV) is significative considering the current use and routine of EV charging. Also, PHEV drivers have low levels of stress since they can recur to gasoline.

Everything it's ok…I'm always calm and easy, I've got my car and I always have my parking space, at work and at home.
PHEV User

On the other hand, PEV drivers have felt high stress levels at least once and have had a high number of problems with EV charging, especially drivers who have not Charging Stations (CS) at home. Some PEV drivers stated that their vehicle had to be towed out of the streets, in situations when they got no battery.

I charge my vehicle every day, either because the battery levels are lower than 50% or because I don't want to take any risks and I choose to have my battery levels always high; I don't want anything wrong to happen to me.
PEV User

Another key aspect to define different charging habits, differ from PEV users that can charge their vehicle at home and the ones that are not. The last ones rely on public and semi-public charging services, consequently, they have experienced way more problems and inconveniences on charging services. Therefore, two different types of users where defined the BEV users, that could charge at home or even at their job installations. And the Stressed BEV users and have not that option.

I value fast charging, only one CSs is not enough, I want a great number of stations.
PEV User with no home charge

I have had a lot of problems, the fact that the posts are always broken is super annoying, and when they are not, they are occupied, sometimes even by not electric vehicles, also Uber Drivers are always blocking the existing posts.
PEV User with no home charge

I want an affordable price, especially at a lower price than charging at home, the supermarket is whom in fact, stands to gain from such services since clients will spend much more money at that establishment than at the CS.
PEV User with home charge

Table 4 - Charging Location per type of user

Charging Location	PHEV User	PEV User with home charge	PEV User with no home charge
Commercial Buildings	0	1	3
Home	11	8	0
Job Installations	7	2	1
Public Parking Spaces	0	3	3

Most of the participants charge their vehicles at home, and at job installations. Although, it was possible to conclude that people who could do that at home and/or charge at jot installations, even PHEV users, use public parking spaces and commercial buildings, at

weekends or when they go out, for any activity. Table 4 refers to the number of participants, divided by type, who mention they've used which charging location. Also, time of charging, depends on CS power, but also on location. At job installations and at home, people their vehicle for 6/12 hours on the spot. At public parking spaces and at commercial building, the situation is different.

I always charge my vehicle at Mobi.e posts 1h around 7 pm, and at weekends at 10/11 am.
BEV User with home charge

At weekends, when I go shopping at Lidl, I use fast charging, during around 30 minutes and sometimes around 1h or even more., because is the time I spend shopping.
PEV User with home charge

I live next to Norte shopping, at a 22v charger I take 4h, during the late afternoon, when all spaces are occupied, I try again at evening, and I leave it there for 3h.
PEV User with no home charge

Considering the charging routines, it was found that the time of charging varied according to the location of charging (see table 5). At commercial buildings, people tend to spend from 30 minutes to 4 hours charging their vehicle, mainly at late afternoon, during the afternoon and at the early evening. Also, most participants use parking spaces, followed by commercial buildings and home garages, the location less used is Job installations.

Table 5 - Time of charging per Charging Location

Time of Charging	Charging location			
	Commercial Buildings	Home	Job Installations	Parking Spaces
Morning	1	0	5	3
Evening	2	5	0	2
Late Afternoon	3	4	0	4
Weekend	6	3	0	5
Total	12	12	5	14

Although, the main concern of this project is understading the customer experience on commercial buildings, considering that a supermarket is included on that group. It was important to discover if people who charge their vehicles at home also used commercial buildings, table 6 indicates so. Although, value offers could increase this number, as it would be confirmed next.

Table 6 - Participants EV charge at Home and at Commercial Buildings

Charges at Commercial Buildings	Home
No	6
Yes	4
Total	10

Location of charging is related with problems and inconveniences. Table 7 presents that the top problem is availability, also related to Individual and paid passenger transport in vehicles based on an electronic platform (TVDE) occupation of parking spaces. For commercial buildings, the second problem mentioned is slow charging, the other stated issues are no client support when problems occur or even malfunctions with CSs, which most commonly mean that it cannot be used. No participant stated that they never had any problem.

Table 7 - Problems and Inconveniences per Charging Location

Problems and Inconveniences	Commercial Buildings	Parking Spaces	Home	Job Installations
Availability	4	4	0	0
Occupied by TVDE	2	2	0	0
Slow Charging	2	0	1	0
No client Support	1	2	0	0
Malfunctions	1	2	0	0
Nothing	0	0	11	5
Total problems	10	10	1	0

Regarding the problems and inconveniences, in general the main problem, referred by 8 people, is availability. In table 8 is possible to see that availability is the first aspect of value, being mentioned by 12 people, meaning that is greater problem to be solved. Also, slow charging the second main problem at commercial buildings, and the fourth aspect, which is another problem to be solved. Considering the aspects, besides the ones mentioned before, the main concerns are price, convenience, simplicity, also client support, and security are mentioned. One regular user stated that charging services at commercial buildings have no value.

Table 8 - Aspects of value at Commercial Buildings per type of user

Aspects of Value at Commercial Buildings	PHEV Users (6)	PEV Users with home charge (8)	PEV Users with no home charge (5)	Total
Availability	3	5	4	12
Price	3	3	2	8
Location/Convenience	2	4	1	7
Fast charging	2	2	2	6
Simplicity	1	4	0	5
Client support	0	0	1	1
No value	0	1	0	1
Security	0	1	0	1
Total aspects of value	11	20	10	

Although the aspects of value are similar from different types of Electric Vehicle Users, some differences can be spotted. Regular users really value simplicity, also a small nuance of price

sensitivity is noticed, who doesn't rely on public charging services tends to be more affected by prices. Convenience is another key difference, because people aren't willing to move to a less convenient location, especially users who don't need to.

Finally, with regard to participants' expectations, every aspect of value mentioned before is also expected in a supermarket charging service. In addition, some extras are mentioned. Hybrid users mention platforms to Eelectric Vehicle charging management, such as reservations systems, also incentives to diversify time of consuming is important for this group. Hybrid drivers tend to expect bold extra services to complement the basic one, such as a car washing system or pick-up system with EV charging for online orders. BEV Users with home charge are concerned with technology to simplify the process such as platforms to manage EV charging, with inflow information, this group desires privileged parking spots, physical evidence, some type of cashback or promotions, or even a free service. BEV Users with home charge are more demanding, they feel like they deserve a great and complete service, distinctive from hybrid users who desire extras, these users desire a complete and focused service. PEV users with no home charge are less demanding and creative, availability and fast charging is TVDE drivers is their main concern, they want a controlled experience. Moreover, this group feels that promotions or cashback, would convince them to be a client of the service in question.

Some type of cashback or so would convert me. Of course, the supermarket location is super important, because I wouldn't go to Pingo Doce deliberately if is not convenient. For me, it will depend on the offers that I'll receive from the supermarket, I wouldn't pay more just to go there.

PEV User with home charge

This service would not be a decisive factor for me, I would not go to that specific building. Although, between that or others that did not offer charging stations, I would choose the first one. It would not be decisive but would be relevant, especially when I'm in a pickle and I really need more battery. It would be decisive if they offer advantages or if it is convenient for daily routine.

PEV User with no home charge

For a hybrid I don't see a great necessity, it would depend on prices, it would only be a commodity not a life charging service. Definitely, it would have to be composed of fast charging stations and guarantee that I can charge my vehicle, to avoid me arriving there, spend energy and not get any in return.

PHEV User

At commercial buildings, a Hybrid and a PEV user with home charge, can park at regular spaces, even though they dislike that. PEV users with no home charge need to charge there. Every type of user would enjoy this condition and definitely would use a charging service at a supermarket.

To conclude, the decisive factors are convenience in form of location, price (only PEV users

with home charge show a bit more price tolerance) and to make them go shopping to a new place, besides the motives mentioned before, are the existence of extra services such as cashback, free charging, or a charging management app, in order for the service to obtain value.

4.2 Understanding the customer experience

The study literature allowed the understanding of the service stakeholders and their relations and who was the most important ones to take into consideration, using a stakeholder map (see figure 5). The main stakeholders identified are UVEs, and the service provider, who is the supermarket management, which could or not be the CS Operator, the energy provider (EMC) is also an important stakeholder. The supermarket customers are also affected by the service, and TVDEs are also important since they are named jay customers and can affect the service experience. After analysing the e-mobility network, in Portugal, we conclude that in order to develop any e-mobility service, Mobi.e SA, ERSE, and DGEG indirectly, via legislations, had an impact on the service traits.

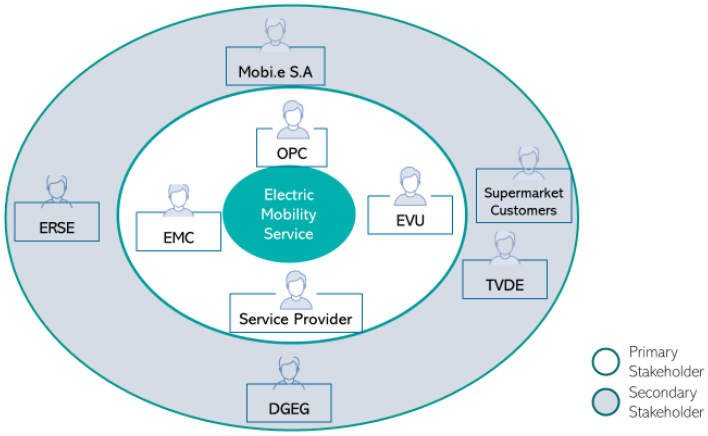

Figure 6 - Stakeholder Map

Personas

The results of the data analysis supported the grouping of potential customers, allowing the creation of personas with different habits, charging traits, different needs, and problems and expectations. Three personas were created in order to support the understanding of the customer experience.

The persona Constança was named after the BEV user with no home charge, she is the stressed user who lived in an apartment in Matosinhos but didn't have a garage able to charge her vehicle. She is a nature lover, and has an active life, uses her Nissan Leaf everyday to drive to work, pick up her daughter, go to the supermarket regularly, to the gym, to the beach or go out with her husband and friends. She is price sensitive, even though the stress of not having where to charge. This persona normally charges her vehicle on public spaces during the day but takes advantage of situations for charge at commercial buildings when she goes out. She values availability and simplicity supported by technology services, and cashback. A detailed view of his profile is presented in figure 6.

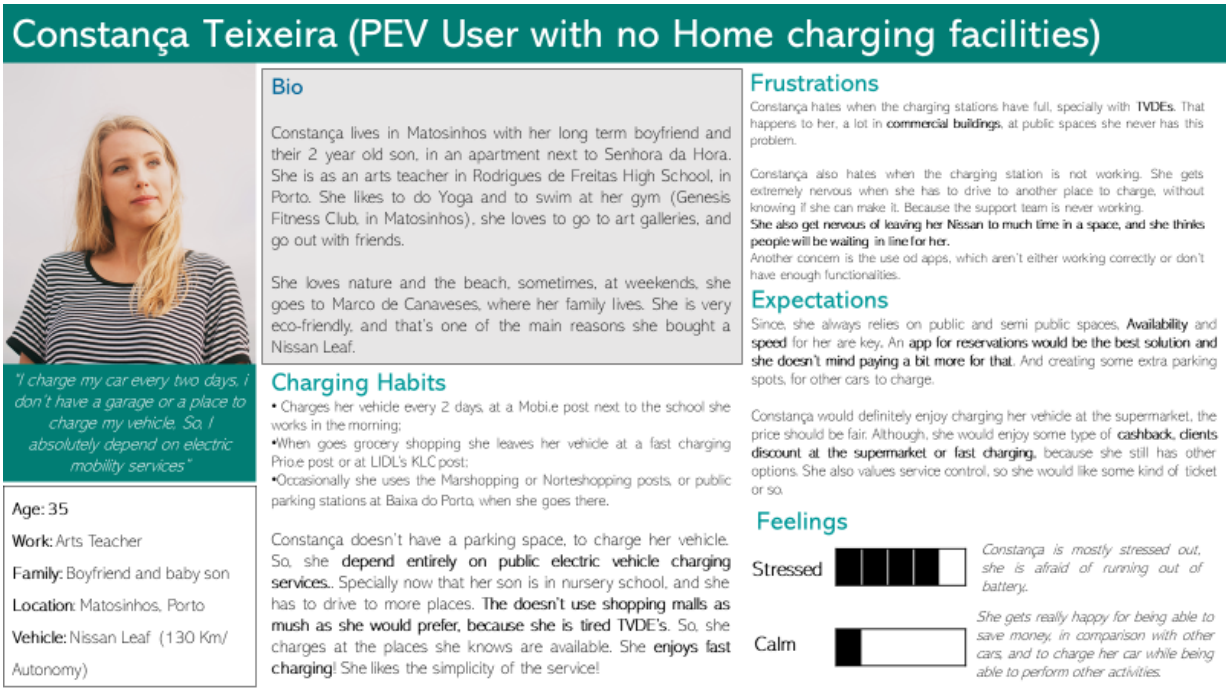

Figure 7 - Persona PEV User with no Home charging facilities

The persona Miguel is the BEV user who lives with his parents in Odivelas, and charges his vehicle at home and occasionally on public charging points when goes out for his dance classes and to meet friends. He hates low availability and malfunctions, but he is price sensitive, because he still has the option of charging at this parents' house. Just like Constança, he values availability and simplicity through technology-enabled services, besides low prices. The location of the charging point is very important, so the supermarket would have to be in a central zone or near his job installations. A detailed view of his profile is presented on figure 7.

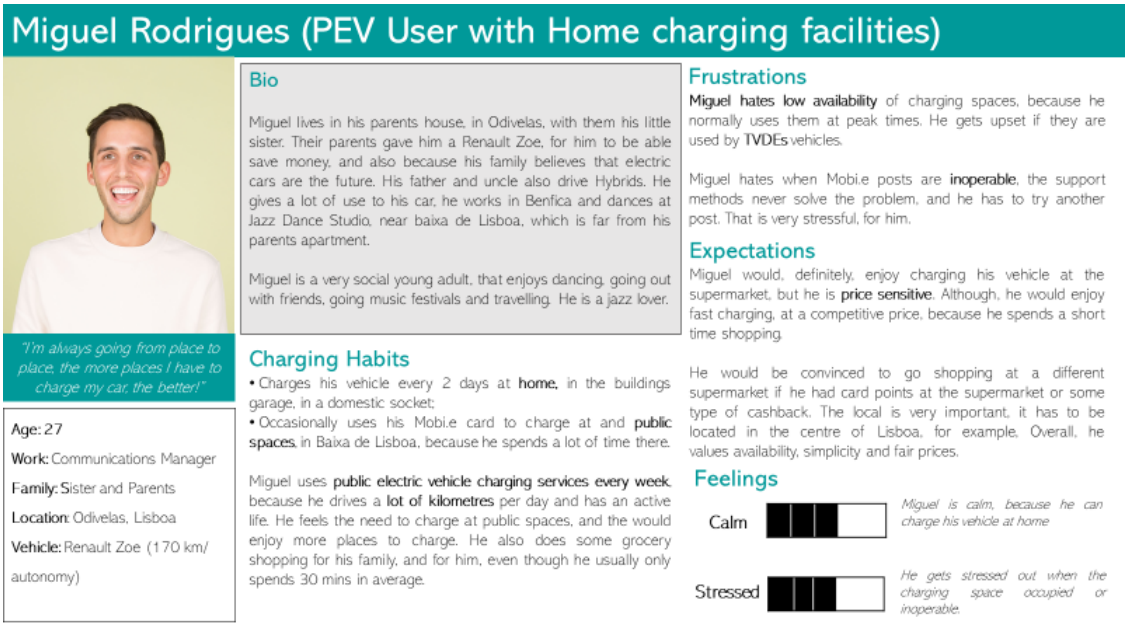

Figure 8 - Persona PEV User with Home charging facilities

The hybrid vehicle user is Rui. This persona is 51 and lives in Vila Nova de Gaia with his family, he can charge is vehicle at home and at work. Occasionally he uses his *Prio*.e card to charge at shopping malls and public spaces, every time he goes out for dinner, goes to the movies, goes shopping or goes for a stroll in general. He does not depend on public or semi-public electric mobility services, so he would enjoy a supermarket charging service for convenience reasons. Rui is price sensitive and enjoys simplicity as well, besides he would enjoy extra services that would make him go to that especific place. He is the calmest of the three personas, because he always has where to charge is vehicle and gasoline.

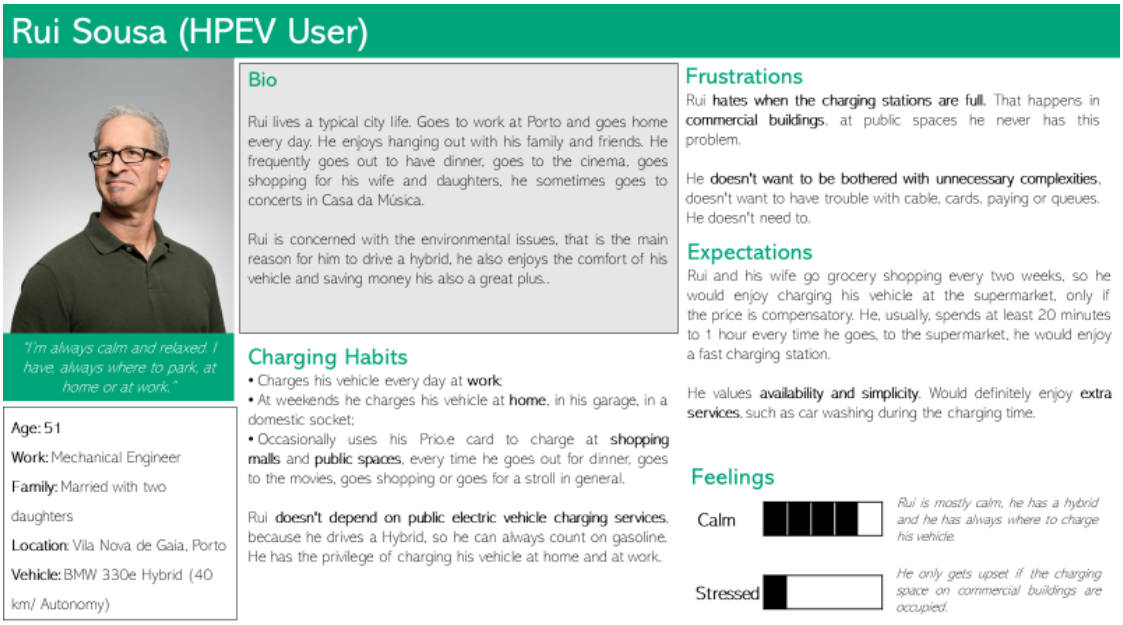

Figure 9 - Persona PHEV

1.3. Mapping the customer experience

Modeling the customer experience provided us the possibility to understand what the customer feels and thinks along the different touchpoints with the service. It provided the actions and reactions in a temporal space since the time where the customer searches for a service that will provide a solution for the need till the end of the service as well through the customer experience map, this model systematizes information from customers' perspective in order to support the service concept conception. The experience map is divided into 5 stages:

1. Before experience comprises the activities before going to the CS, this includes checking battery levels, deciding to charge vehicle, finding charging stations and deciding where to charge. The experience requirements are availability, convenience, and information. The artifacts required to accomplish these activities as desired are an App (e-roaming) and an EV.
2. Next, the initiating experience is composed of driving to the station and parking the vehicle, that requires availability, control, accessibility, information and privilege parking. The artifacts defined are an EV and physical evidence, so that regular drivers don't confuse this parking spaces with others, and EVUs can find those spaces as easily as possible.
3. The charging stage implies the need for directions, ease of use, safety. The artifacts needed are an EV, a charging grid and a CS, cables and an e-mobility card.
4. In the shopping stage, is required information and convenience, so the waiting per se involves picking groceries, paying and carrying bags.
5. The ending experience is composed of the activities finish charging and driving away. This experience requires directions, speed, and ease of use, and the artifacts needed are the same as when the experience is initiated.

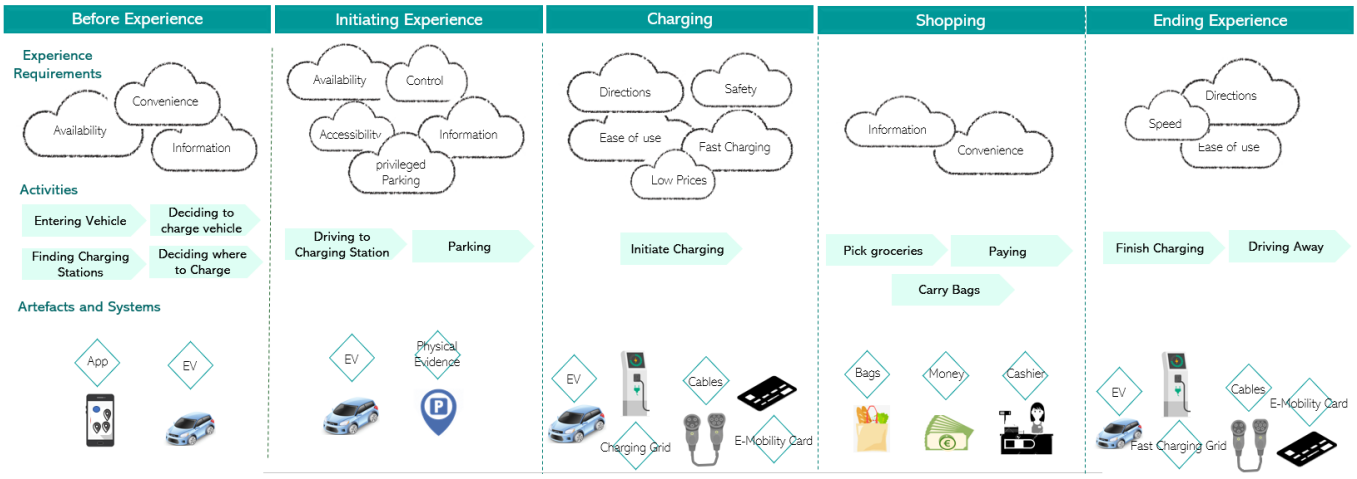

Figure 10 - Electric Vehicle Charging Experience Map

In Appendix I, in order to understand the customers' experience from a general point of view, Driving an EV and Go Grocery Shopping experiences are crossed to support the

demonstration and comprehension of the proposed service's value. The solution arises with the opportunity of EV charging during a standstill time of the vehicle, in the meantime, users undertake a distinctive experience. Furthermore, the respective experience, performed during the uttered standstill time, forms a recurrent activity, a necessity for family units, which is currently or potentially part of an EVU's routine. With regard to EV driving experience, it is presented EVU's pain points involving parking and waiting. Deciding where to charge and finding charging stations are activities seen as opportunity points to improve the customer experience. Considering going grocery shopping's pain points from the customer experience, it is concluded that Waiting in line for cashier and *Paying* are aspects of discontent. Hence, the new service can create solutions for the moment when customers look for supermarkets, are parking and are paying. In turn, going to the supermarket, solves parking and waiting problems of the driving and EV charging experience.

The customer journey involves all activities and events related to the delivery of a service from the customer's perspective. Firstly, the customer journey of the persona Constança, who drives a BEV and does not have access to home charging facilities, is mapped in figure 10. This kind of user checks his battery levels and gets concerned since the its low walue, and that makes him drive to a public charging place. Finding charging stations can be done through users' previous knowledge or via technology, the applications mentioned by customers are Chargemap App, Mobi.e App BMW I, navigation unit ConnectedDrive or through the mobile App Charge Now, and Renault Mobility – Autopartage. When arriving at that place, that user has to wait for a parking space, due to low availability problems. After parking and initiating charging, that user waits for the battery levels to get high, she finishes charging and drives away.

Figure 11 - Charging vehicle on public places Customer Journey by BEV user with no home charge

Secondly, the CJ of Miguel, the user with a BEV who charges his vehicle at home, is mapped (see figure 11). That user tippicaly goes out, then at that place, he finds a charging station and decides to charge his vehicle. Since, those places are crowded, by TVDEs for instance,

Miguel has to wait for his turn to park. After parking and initiating charging, that user waits for the battery levels to get high, finishes charging and drives away.

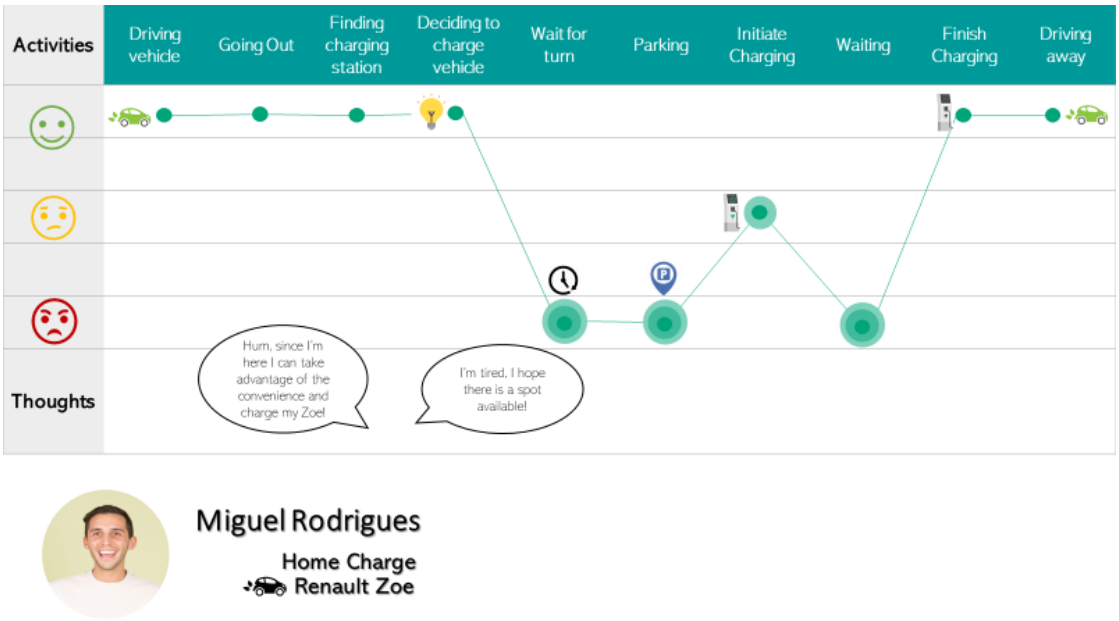

Figure 12 - Charging vehicle at public place by BEV user with home charge

Finally, Rui, who owns a PHEV, simarly to Miguel, goes out and for convenience reasons and decides to charge his EV. Since he is not willing to wait for his turn, this PHEV only parks his vehicle if it's available. After parking and initiating charging, that user waits for the battery levels to get high, he finishes charging and drives away. This CJ is presented in figure 12:

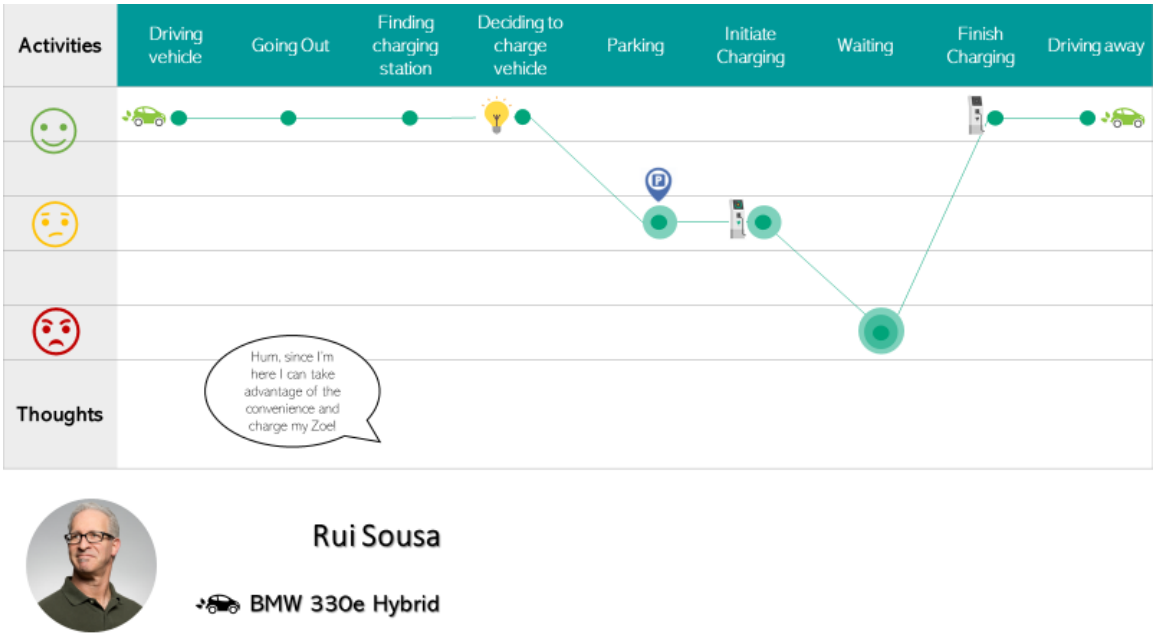

Figure 13 - Charging vehicle at public place by PHEV user

Hence, based on the CJs described before, some of these have touchpoints are interesting and should be further analysed. As described before, the decision to charge vehicle at public places may depend on need or convenience. Parking may involve two paths, at the scenarios where parking spaces are occupied, a major pain point is represented. BEV users are willing to wait. On the other hand, PHEV users are not willing to wait and decide to park at a regular spot, upset with the situation (see figure 13). This touchpoint is an exception of the regular path of successfully charging a PHEV on a public space.

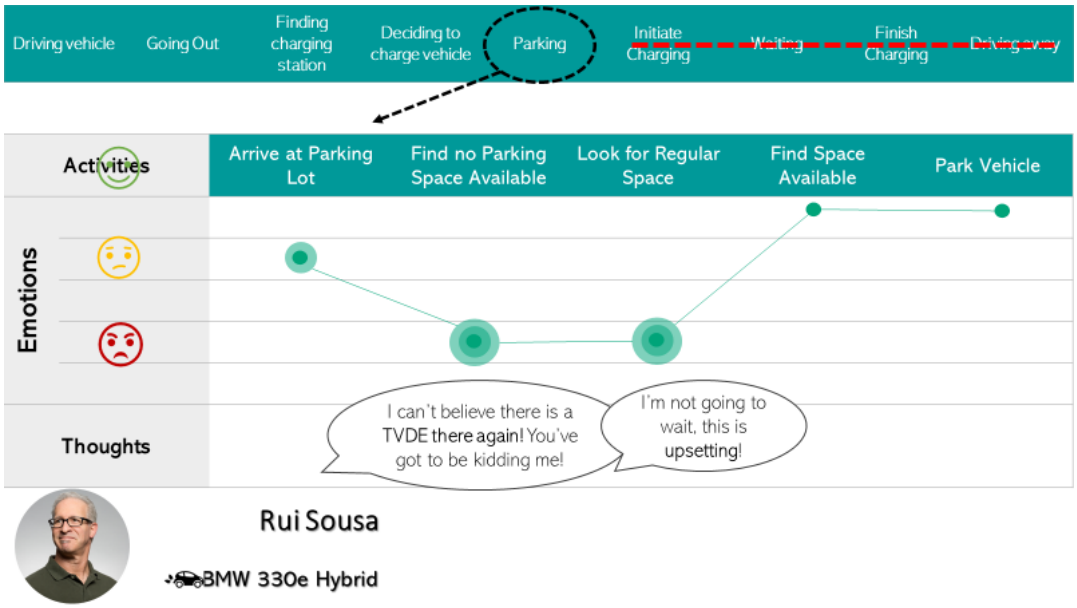

Figure 14 - Failing to park vehicle at charging station Touchpoint

When parking successfully, the activity of Initiating Charging is triggered, this touchpoint is available on Appendix J. This follows the same patterns for all user personas. Customers utilize a charging grid, an e-mobility card and vehicle cables, the user is able to charge his vehicle simply. Thus, the only concern is the payment, no user wants to pay. Everyone uses a RFID communication method, with direct debit payment. The cards that participants most use are *EDP e-mobility*, *Prio*.e and *Mobi.e* card. By law, the systems available must be compatible. Although, participants also mentioned the usual malfunction of public machines and no client support. The following Touchpoint presents this pain point in customers' perspective, with no specific persona. In figure 14, it is possible to see that the regular customer journey is not successfully completed. Because in the touchpoint of failing to initiate charging as is presented, the customer calls support line presented on charging stations unsuccessfully, they attempt to request support at the building which results in him being indicated to go to the closed charging station, so they drive away very unsatiated with the service.

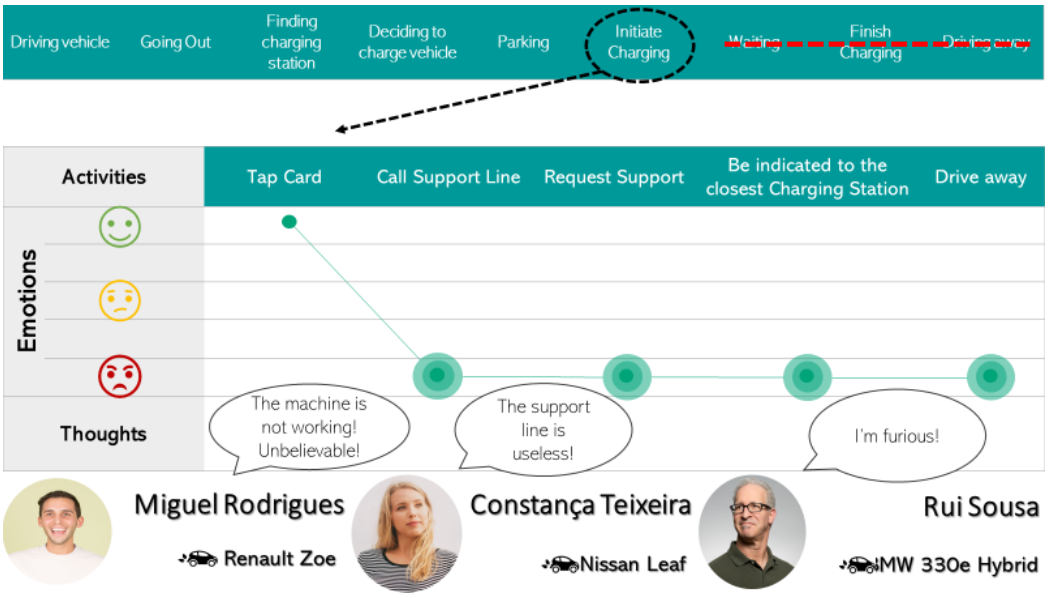

Figure 15 - Fail to Initiate Charging Touchpoint

Waiting at public places follows the same patterns for each persona. Users check time to full charge, then at the waiting activity, participants described going to the movies, going shopping, grocery shopping and having meals. A common aspect found is that users spend some extra time in commercial building, because their vehicle is still charging (see appendix K). Finish Charging is a straightforward touchpoint, just as the initiating charging. Although, when it rains every activity performed at this touchpoint is a pain point (see appendix J). In addition, at commercial buildings, finishing charging, does not always mean the journey ends with the EVU driving away. People tend to get nervous if their vehicle is charging for a lot of time. Consequently, users feel that they are abusing the service and get anxious. Due to to this concern, customers go outside, remove their vehicle from the charging station, and park it at a regular place, coming back inside the building and continuing shopping (Appendix P).

4.3 Mapping the new Customer Experience

After analysing the three customer journeys mapped and its pain points, these pain points must be addressed and solved in order to present the desired customer path with no low moments. After an initial understanding and mapping of the customer experience, the method moved to the ideation phase.

In order to expedite findings and ideas from the target audience, a co-designed workshop session was hosted, utilizing SD tools such as customer journey and brainstorming, the results of this meeting allowed the discussing of the service system was the consolidation of CEM, and development of new innovative solutions:

Table 9 - Workshop Results

Pain point	Solution
Lack of availability	Reservation App; App that allows affluence information; Consumption balance incentives;

	10 parking spaces; 6 charging grids; Fast charging grids; Time of use limitations; Grids stop automatically from charging and users are able to disconnect the cable and use it; Physical evidence that indicates the parking spaces.
TVDE occupation	Extra spaces; Special parking spaces; Supermarket card or code (QRCode) is the only way to obtain price advantages (control).
Payment	Fixed low pricing; Discounts on supermarket; Cashback; Points on card; Discounts on other services.
Malfunctions	Support team; Instructions of use at App and at service setting; Compensation rewards;
Spend extra time waiting	Fast charging.
Rain	Parking spot with rooftop.
Carrying bags	Privileged sparking next to the door.
Lack of extra services	Car washing; Providence of cables and cables connectors; E-Roaming app; Vehicle to grid services.

The CVC represents the set of service offerings and respective interrelationships that enable customers to co-create their value constellation experience for a given customer activity. This tool was used to map the service concept of the existing going to the supermarket experience. On Appendix R, the defined service offerings are mapped as: online store, pick up orders in store and home delivery orders, plus the physical store, where is offered parking, and supermarket card discounts. The entities that make this possible is the supermarket, delivery partners and energy retailers. Figure 16 presents the new customer value constellation of going to the supermarket and EV charging supporting the development of the new service concept. The green colour (with thinner outlines) represents service offers for EVU: Parking and EV charging, E-mobility card and E-car washing that is connected to the previous card discounts, e-charging client support, and charging station management. Beyond service entities that already serve the concept, a EMC is included to retail energy, the Supermarket itself is the CS operator.

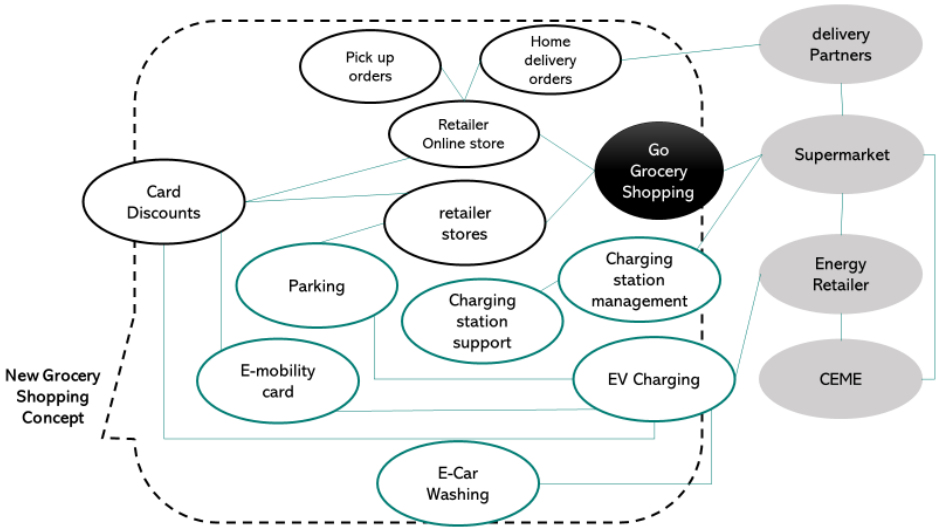

Figure 16 - CVC New Shopping Service Concept

The next step is the design of the service system in accordance with the concept developed on the new CVC. To accomplish this result, the SSA and the SSN (designed per persona) is developed, establishing the set of customer activities and how they are supported by the service.

The SSA depicts the different tasks of the new shopping experience on the top row, involving finding charging stations, making charging reservations, parking, EV charging, getting car washes and shopping. This new service experience, in addition to shopping and EV charging, is complemented with extra service supported by an E-roaming app, with a reservation system and information about the charging stations' availability and an e-car washing machine.

The SSN presented in figure 17 covers the navigation for BEV users with no home charge. The customer activities are initiated with the decision of going grocery shopping, the service can support this decision through an app with e-roaming. So, customers check the app interface to find the supermarket's location, the number of grids available, inflow tendencies and price. Then she makes a reservation for a designated charging grid, obtaining the price she will pay and the ID of that grid. Next, this user drives to the supermarket, which can be supported by the same e-mobility App, through a GPS system. In order to initiate charging, the service provides a charging grid interface that indicates how the activity is performed and the backstage IS is responsible for the RFID communication process with the EM card and the EM supermarket card. The shopping activity is not a core service of this case, although the payment activity is considered to be important. The supermarket information system reads the information of the customers EM supermarket card, including data from previous charging activity stored in the database, and processes the activity. Finishing charging is performed similarly to initiating charging. Although, in this turn, data from the charging consumption is registered in the grids' system and in customers' card system, and the payment is completed through direct debit.

The SSN for the PEV owners with home charge, presented on figure 18, initiates when the users are driving his vehicle to go out, then, using the App, he can find the designated charging station, checking its location on map. Then, this type of users can check availability, by looking for inflow information and the number od available charging grids. He also can check prices which is decisive when deciding to charge his vehicle on that supermarket. After

arriving, he parks his EV, and initiates charging, goes shopping, and finishes charging following the same patterns as the previous persona.

Lastly, PHEV drivers follow an initial similar path as Miguel, although after checking prices the app offers them information about the E-car washing service, with instructions, pricing and duration. Rui drives to the supermarket, he parks on the designated parking space for car washing users, then he initiates charging and initiates the car washing on the designated washing machine, pays with his credict card and goes shopping. When he arrives, customers do not need to do any more activities concerning the car washing service, so he finishes charging and drives away.

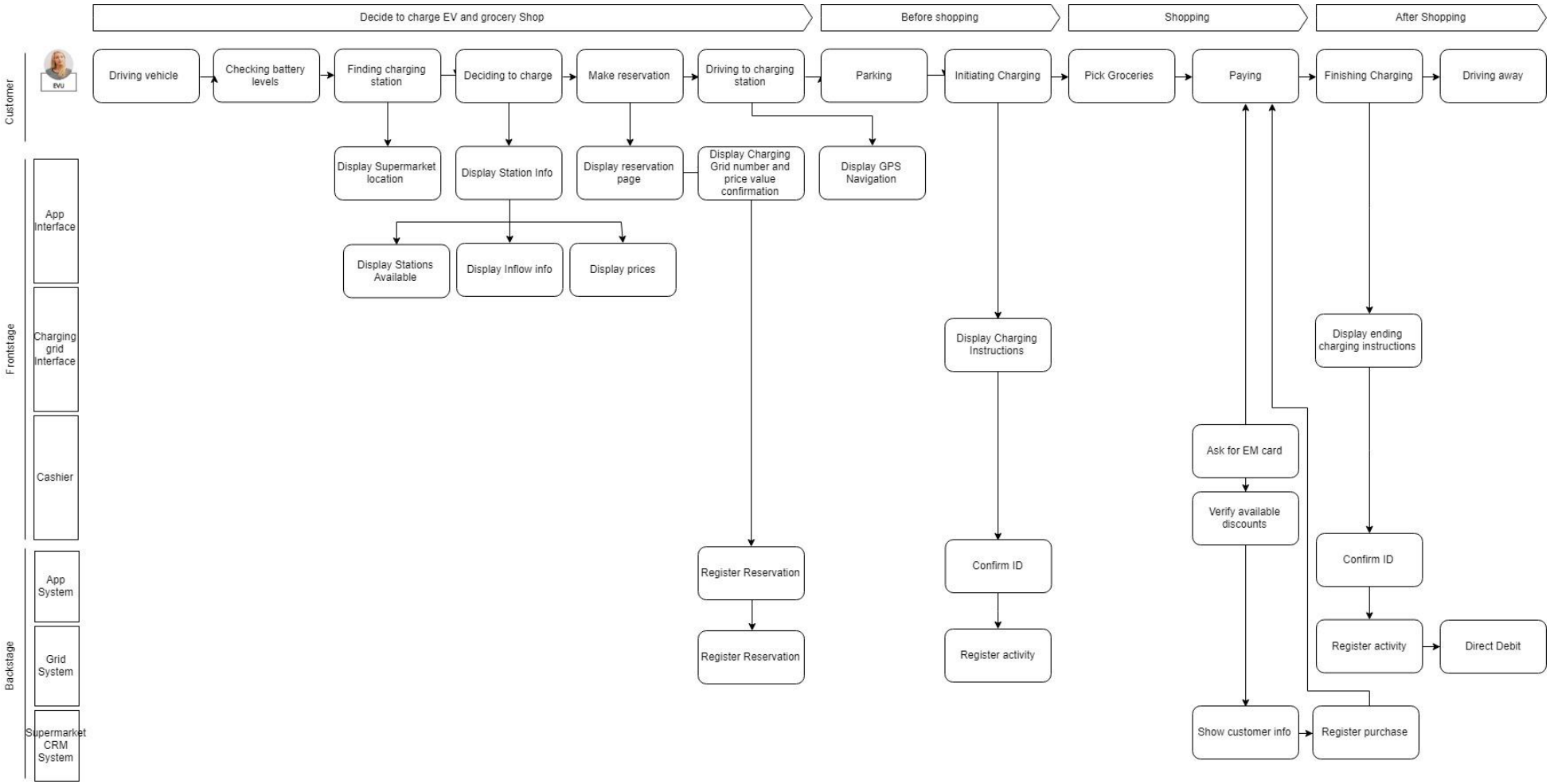

Figura 17 - PEV User with no home charge Service System Navigation

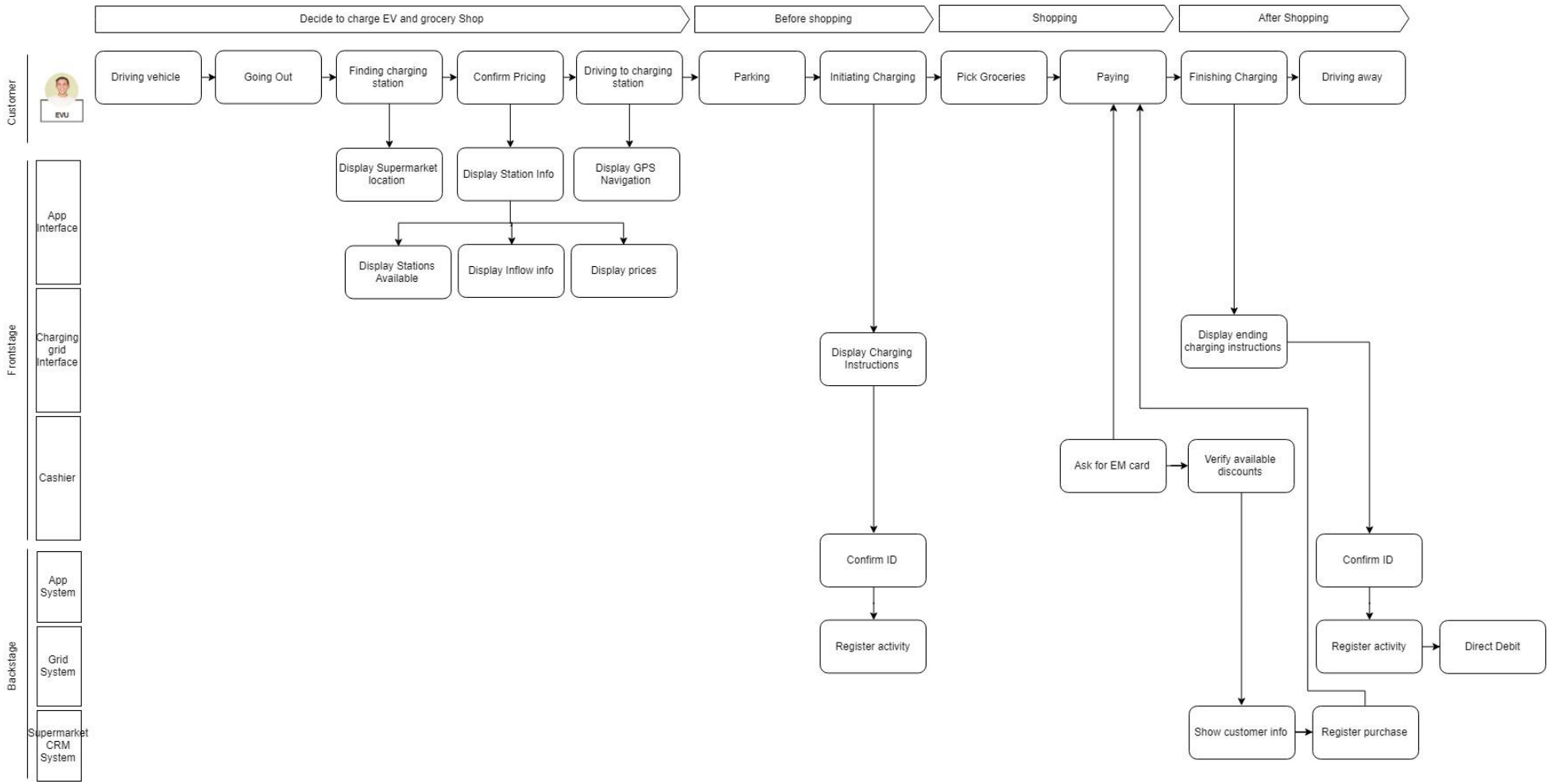

Figure 19 - PEV user with home charge Service System Navigation

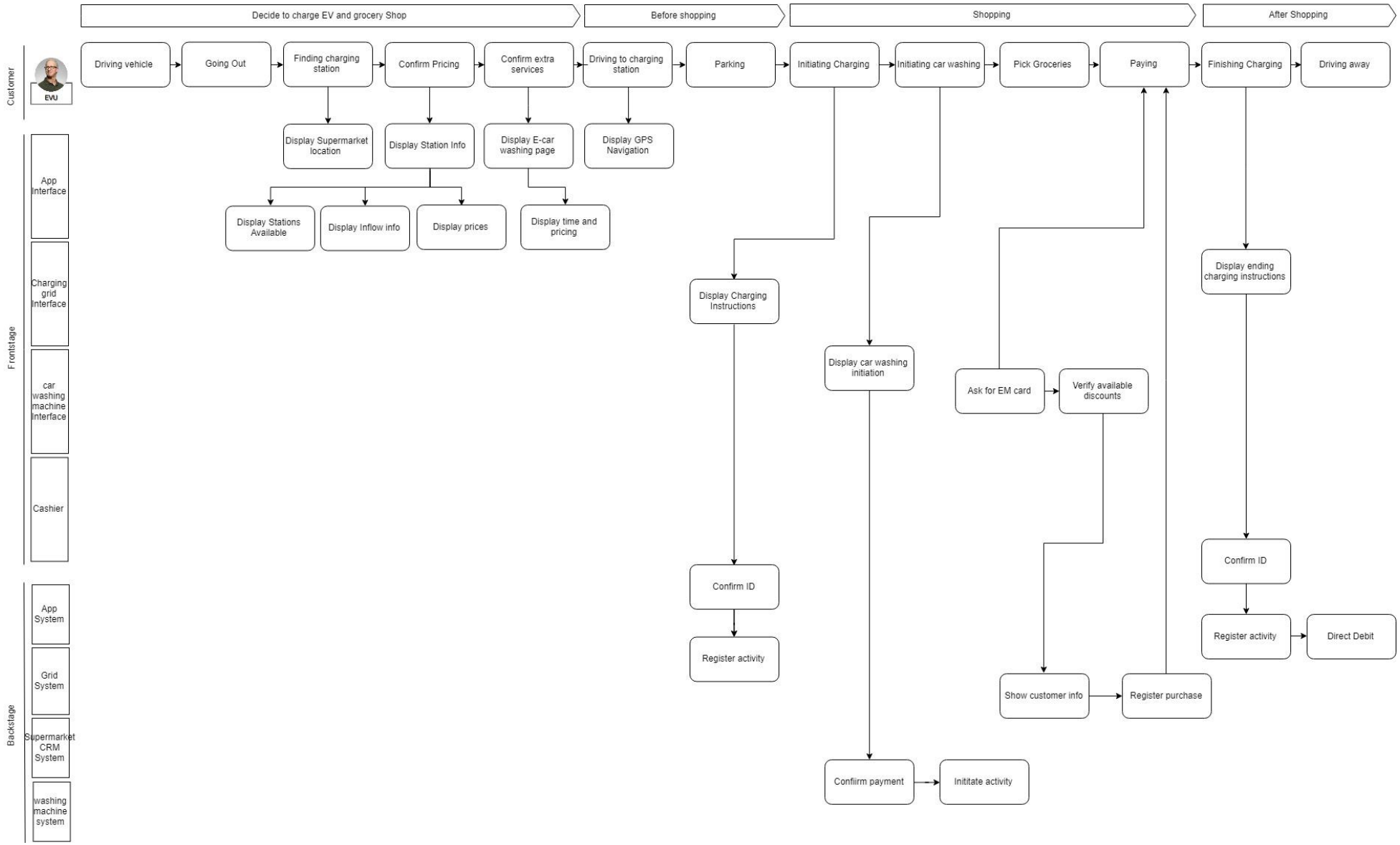

Figure 20 - PHEV user Service System Navigation

After analysing the service system, new CJs are created in order to map the desired path for each persona. For the BEV user with no home charge, after checking the battery levels and deciding to charge vehicle, this user can find this supermarket on an e-mobility app, developed especially for the designated supermarket. And then she decides where to charge the vehicle following specific parameters to enhance her decision to use that supermarket, which is mapped on the touchpoint of that activity in figure 18. According to the interview results, the critical factors for this persona to decide where to go is convinience. This persona relies on public charging stations, so the best solution to guarantee availability is through a reservation system. After driving to the station, these users park their vehicle successfully, go grocery shopping, then finish charging and drive away.

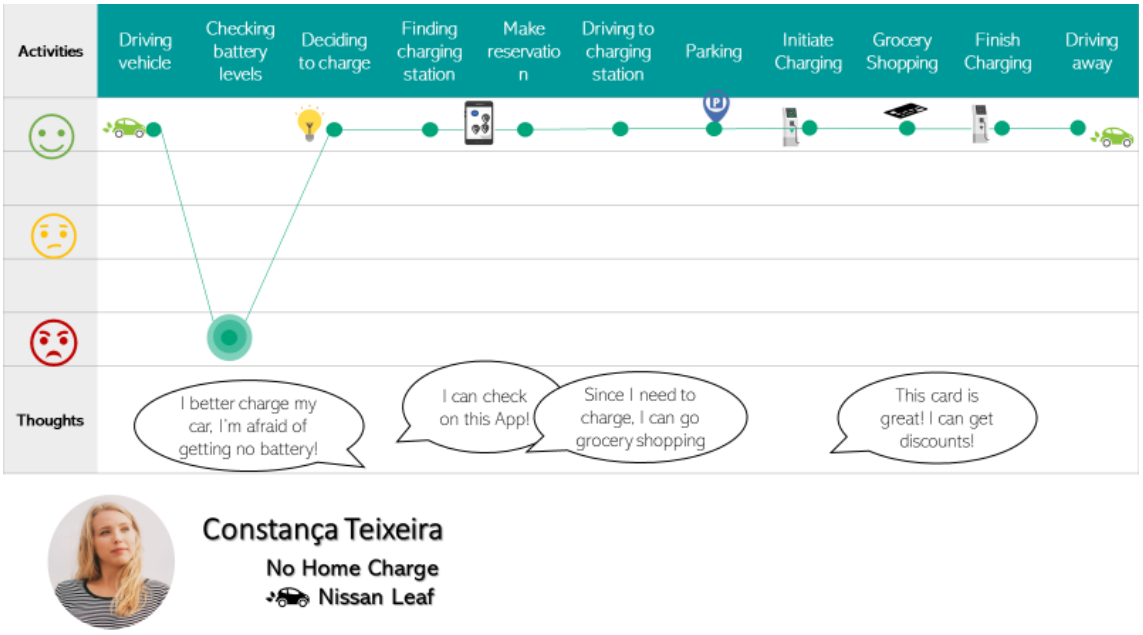

Figure 21 - New BEV users with no home charge Customer Journey map

The decision process of going to the supermarket is different from each persona. Constança takes her decision, following three aspects: Convenience, fast charging grids, and availability, which is guarantted through the reservation service (see figure 21).

Figure 22 - Deciding where to charge new Touchpoint by BEV User with no home charge

Miguel follows the same journey as Constança, but instead of making reservations his decision takes price into consideration (see figure 22). The service app will provide him information on prices, discounts, number of available grids, and inflow tendencies, this touchpoint is presented at Appendix M.

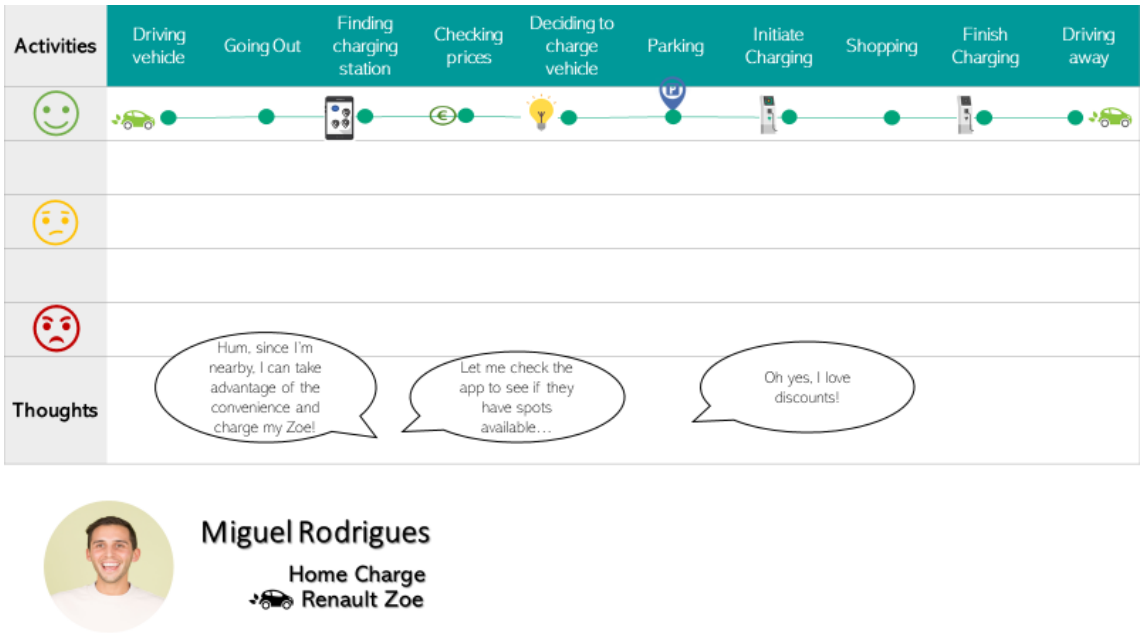

Figure 23 – New BEV user with home charge customer journey map

The customer journey that PHEV users take (figure 23) follows the same decision path as Miguel with additional concerns about extra services. After parking and initiating charging, PHEV users initiate the E-car washing service and go shopping, then they finish charging and drive away. At Appendix N, the touchpoint of finding charging stations is presented, where it shows that Rui thinks about convenience and fast charging, then he enters the designated app, he checks availability and pricing and confirms extra services that make him make his decision.

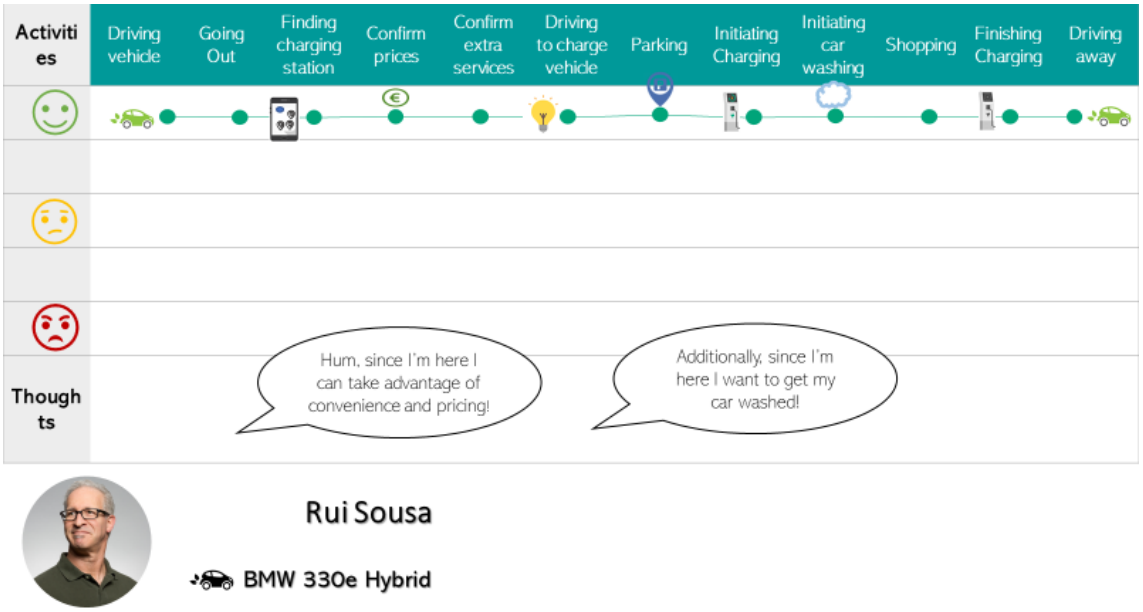

Figure 24 - New PHEV users Customer journey map

The current experience of charging an EV on public places showed usual malfunctions of charging grids, these problems can happen, so service providers should create problem solving policies to improve users' experience. In figure 24, the failure of charging a vehicle touchpoint is presented. In this case, customers asks for the service support team, who solve the problem, if not, the customer obtains a compensation for the inconvenience, either a free charging voucher or, if the customer EV does not have enough battery to move to the closest charging point, the service offers a read assistance service to charge his vehicle with the sufficient energy. This extra service implies the creation of support procedure, and the extension of an employee's scope, who is designated to be the support technician.

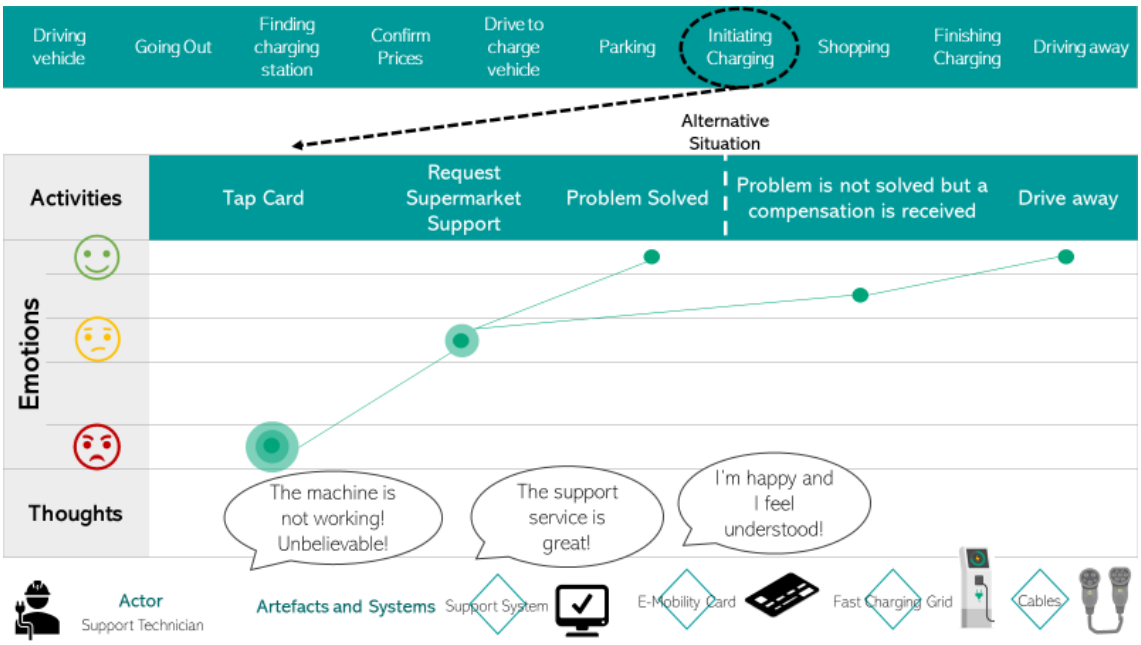

Figure 25 - Failing to initate charging new Touchpoint

At the new shopping touchpoint, at Appendix O, users check time to full charge and monitor it from the app, while grocery shopping, they pay, and are able to obtain special card points that result in discounts. After, they carry the bags to the vehicle and put it inside it, which is less troubling than the regular experience, due to privilege parking spaces. In order for the supermarket to guarantee profits, the user should be motivated to purchase, an app supports the charging progress and, also manages users charging records at the station, and purchases converting those into discounts.

Thoughout the ideation stage is possible to verify the proposed service solutions that are explained in detail at table 11, bellow:

Table 10 - Service Proposed Solutions

Proposed Solution	Description	Benefit
EM Supermarket app	Mobile app connected to an EM supermarket CSs card.	Enhance the decision process of potential customers; Enhance finding this charging station; Improves parking availability; Engages customers.
E-roaming service	Charging service providers are connected to a roaming platform. Enabling the supermarket location, a GPS system, information of charging grids stative (available or occupied) and inflow charts with the time of use recommendations.	
Reservation	Processing secure online	

service	reservations made through this app. The data is then passed onto a backstage system, the reservation is processed and only the that customers' ID card can unlock that grid. This service is charged as an extra.	
Support service		Facilitate the successful functioning of the service, especially to solve circumstantial problems and malfunctions. Customer satisfaction.
Charging cable providence	Users can freely rent a cable or cable connector to use on a charging grid.	
Service recovery policy	In case of malfunctions of the charging station, that disables EV charging, the problems are solved by a designated technician from the support team. If the problem is not solved, a service recovery policy is put in practice. The procedures suggested are a voucher for free charging and if the client has no sufficient battery until the closet charging station, the support team calls towels service.	
Service setting		
Charging Grids	A higher number of charging grids should be installed, the average number of charging grids on commercial buildings is four, so six charging grids is recommended. The charging grids should be of fast power.	Since the time spent on grocery shopping, is shorter that shopping in general, people will spend less time on supermarkets, fast charging stations is the solution to complete 100% or almost 100% of battery. Reduces stress levels from customers who feel they exploit the service. Improves parking availability. Provides simplicity of experience and comfort.
Parking Spaces	Extra parking spaces are suggested, using a technology that allows cables to disconnect from grids, users can use extra spaces and use the grid, even if the previous customer has not arrived. Four extra parking spaces should be created.	
Instructions	User instructions shall be available on the EM app and on charging stations, in case a user feels confused in the moment of initiating and finishing charging.	
Information and direction signs	Signs support customer orientation, as well as avoiding regular drivers to use EVU parking spaces.	
Privilege parking	The parking spaces should be next to the entrance and complemented with a ceiling coverage.	

Service Monitoring		
Charging Time	Limit charging time to 30 minutes, since that duration is enough to charge 80% of vehicle batteries. After that, the grid stops charging automatically and the cables can be disconnected.	Helps misuse of the stations, such as TVDE drivers and facilitates increasement of parking availability.
Support team	A support team should be formed with supermarket's employees and be available for anytime for customer satisfaction.	Customer satisfactions and problems solving.
Managing demand and capacity	After understanding demand patterns. Strategies for matching service capacity and demand can be developed, such as smoothing the demand fluctuations and avoid peak times. Promotions can be successful, hence, the suggested promotion is to lower prices of consumption during the week gradually upper prices until late afternoon, for example.	Improve chances of parking availability; Facilitate service provider management of energy consumption avoiding potential energy overuse.
Pricing	The pricing strategies should be mark - up, fair prices, lower than competition.	Enhance a higher number of customers;
EM supermarket card	Customers should be able to create an account on e-mobility supermarket, they are able to turn their service consumption into discounts on the supermarket. To clarify, charging grids manage the charging duration, store it and the supermarket convert that value into points. Also, it is suggested a promotion technique for frequent users who experience EV charging service, such as counting of the number of times a respective user charges their EV there, on a specific number of times, they earn a price or extra service offer.	Customer retention; Customer engagement; Customer loyalty; Price advantages for customers.
E-car washing service	This auto wash service is a service used to clean the exterior of EVs. A machine is installed in one parking space, where users can only park here if using the car wash service. The payment is an extra, and is conducted by credit card, before	Extra services enable an enhance of a higher number of customers and improve customer retention. For customers, this

	initiating the wash.	service is considered very convenient.

Personas currently have distinctive needs. They have different charging habits, but the revealed problems are the same, the differences of what they value are significant, although some service expectations differ, it was found a service concept that balances this for the three personas, since setting a different system or service offers at the first stage would be the best solution. The new service concept was designed to serve all designated personas and generate a unified service, not customized per use. What distinguishes it from other services' offerings is the complexion of the service, customization through the e-mobility card and the guarantee of customer satisfaction.

Prototyping and Reflexion

The last stage of the project focuses on prototyping. Authors state that prototyping applies to the design of the service encounter. Although, this project does not include the service encounter, only its system. Via low-fidelity mock-ups and a storyboard we were able to enhance the visualization of the service concept, in order to support future work. Thus, it allowed the understanding of service suggested improvements, such as the e-mobility application designed for the supermarket. Figure 33 pictures the general service experience, beginning with customers desire to go shopping, followed by charging stations search, through the EM app, and the charging stations availability (for instance). EVU drives to the supermarket, parks his vehicle easily, and initiates charging by tapping his card, and connecting cables. Then, he goes shopping, and at the payment moment he shows his ID number to prove that he is an EV customer on their infrastructures, to conclude the experience, he finishes charging and drives happily away.

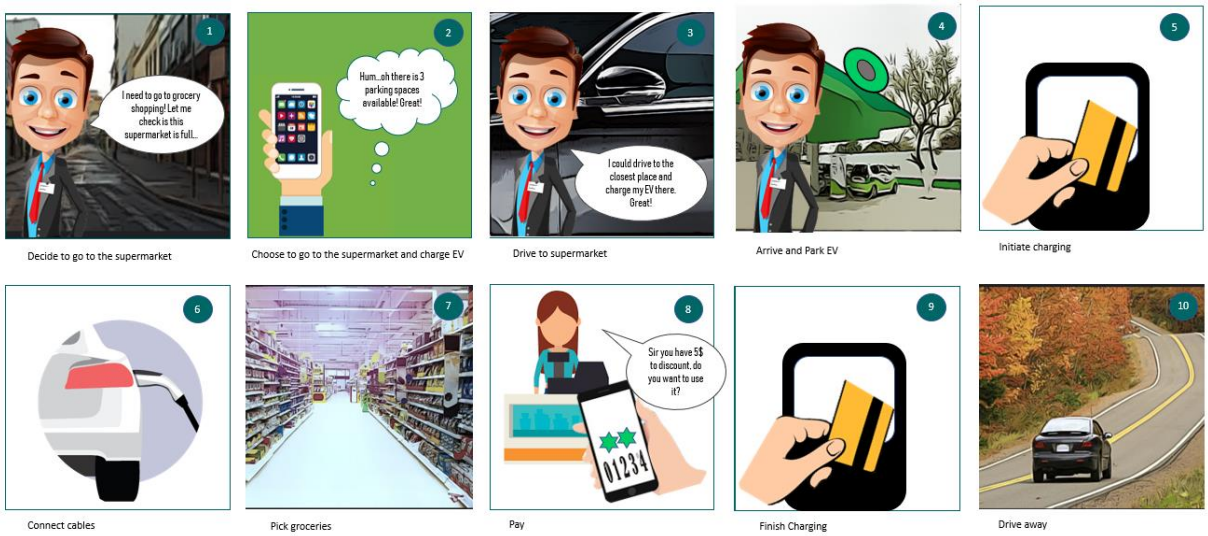

Figure 26 – Service experience Storyboard

This process required iteration and creativity. Designing the customer experience demanded going back to analyse every detailed information, reformulation of results as they were being drawn up. Customers involvement and co-design was also another critical aspect for the development of the result solution.

5 Conclusion and future research

This project has aimed to design a service electric mobility charging on a supermarket infrastructure, through the development and follow-up of a service design method. The expected objective was the development of a service able to control and manage charging vehicles connected to the building electric network, payment and parking. So, the second main objective is the application of a Service Design approach that fits these problem' specificities.

In order to understand the new emergent opportunities among EM services, a study of business models in electric mobility was undertaken, the electric mobility network in Portugal was also structured, the services provided were analysed, and the overall electric mobility context was understood. Based on this review, it is possible to conclude that technology-enabled solutions to meet transportation and charging needs, have not yet reached its full potential. Also, there are different business models, such as e-roaming, e-car sharing, V2G. In Portugal, electric vehicle users can access CSs by a card provided by a designated EMC with RFID or through an API or via other electronic methods, which may be provided by an EMC. The EM value chain is composed of four main functions: 1) manufacturing, 2) development and installation, 3) network operation, and 4) sales and marketing (Henso, 2019). These business models vary widely and may serve one or some functions. However, no clear model has yet emerged for delivering this service, and few studies evaluate existing models in detail. This leaves an open door for new business models and services that can evolve and meet the needs of its users.

The customer experience research was undertaken in order to understand the customer experience of electric mobility services. The exploration stage focused on customer experience findings and a deep understanding of customers. This allowed the identification of customer needs and desires, using interviews as the qualitative method to collect data, that was converted into the definition of three personas (HPEV owners, BEV owners with home charge and with no home charge). Also, a customer experience map and customer journeys were crucial tools to capture users' experience, by mapping activities and scrutinizing feelings, thoughts, and aspects of concern, the exploration of the service context and customers were successfully accomplished. The findings of this study showed that the current stage of service electric mobility offerings was very troubling. Availability, charging duration, technologic malfunctions, simplicity, convenience, and price are themes very present on customers' minds. We also concluded that electric mobility charging services connected to supermarkets' infrastructure would be considered of great value for customers.

A theoretical study of service design, design process, tools, and methods was also performed to understand how can service design methods be applied to electric mobility services. This sustained the applicationof the SD process that was able to correspond to this project's specific traits, needs, context, and goals. Since no SD model was ever applied to electric mobility services, a variety of SD techniques and tools were captured to develop the solution. This process was composed of three stages with different design purposes: 1) exploration, 2) ideation and 3) prototyping and reflexion. The exploration stage resulted in the mapping of the customers' experience. This allowed the advance to the ideation phase where new CVC was the resolving tool to represent new service concepts that can improve the current service offers and meet the initial proposed solution of the project. The new service provides to the users shopping, parking, EV charging management, availability, security and, low-cost EV charging. In addition, this service is proposed to offer client support, e-roaming, a reservation service, special promotions registered throught user's connectivity with the supermarket establishment, using an e-card, plus it offers an e-car washing service. The owner of the infrastucture itself can function as the OPC and is able to acquire, engage and retain customers. The new service concept was designed to serve the three personas generating a unified and customized service. This service distinguishes itself from other services, by adding more value to its offer. The ideation stage closed with the application of the SSA and three SSNs for each persona and was complemented with new CJs. Prototyping and reflexion were the focus of the last stage of the process. Validation with owners of commercial buildings' infrastructures was not accomplished due to lack of time restrictions, that hundered a solid constact. Finally, the implementation phase is not applied in this SD process, it implied service providers acceptance and will to follow the procedures to construct, in practice, the proposed solution. This model allowed the creation of this proposed solution it included a deep involvement of customers, the customer experience study is very complete, and for future e-mobility services is very insightful. Another critical aspect of the model is the ability to connect two distinctive customer experiences and jointly create a new one, this enabled service completion, it not only designed as electric mobility service, but the grocery shopping was also a concern on how to integrate both.

Considering, the limitations of the work developed, affected by time restrictions, the study did not involve owner of a commercial infrastructure. Following, future work can be further explored with the addition of this stakeholder's perception and validation of the solution proposed. The designing the service encounter and the service implementation is also interesting to be elaborated prospectively. Regarding the project contribution, the solution designed serves as a launching pad to implement an innovative electric mobility service. The SD-based model crosses exploration tools (CJ, CEM), ideation tools (CVC, SSN) and prototyping (mock-ups and storyboards) from other models. Hence, it presents the models explained above and clarified service solutions.

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APPENDIX A: Informed Consent

CONSENTIMENTO INFORMADO

Estamos a solicitar a sua participação para um estudo no âmbito da dissertação do Mestrado em Engenharia de Serviços e Gestão. Este estudo tem como objetivo estudar a experiência dos ultilizadores de veículos elétricos, essencialmente, no que toca ao carregamento dos mesmos. A sua participação numa entrevista fornecerá informações interessantes para este estudo. Estas entrevistas serão gravadas para possibilitar a sua transcrição. Só iniciaremos a gravação após a sua concordância. A informação recolhida é estritamente confidencial e será apenas utilizada no âmbito deste estudo, sem identificar individualmente os entrevistados. Para qualquer esclarecimento adicional, poderá contactar Bárbara Sobreiro (barbara.ramos.sobreiro@gmail.com), da Faculdade de Engenharia da Universidade do Porto, Rua Dr. Roberto Frias, s/n 4200-465. O investigador: Nome: _____

Assinatura: _____ Data ___ / ___ /___

O participante: Declaro ter lido e compreendido este documento, bem como as informações verbais fornecidas e aceito participar nesta investigação. Permito a utilização dos dados que forneço de forma voluntária, confiando em que apenas serão utilizados para investigação e com as garantias de confidencialidade e anonimato que me são dadas pelo investigador.

Nome: _____

Assinatura: _____ Data ___ / ___ / __

ESTE DOCUMENTO É FEITO EM DUPLICADO: UM PARA O PARTICIPANTE E OUTRO PARA O INVESTIGADO

APPENDIX B: Electric mobility charging services Interview Guide

Perguntas:

- Idade:
- Sexo:
- Atividade profissional (ex.: trabalhador, estudante, etc.)
- Com quem vive?
- Qual o tipo de veículo possui?
    - No caso de possuir um veículo elétrico qual é o tipo/marca/modelo que possui?
        - Qual é a capacidade da bateria do seu veículo? (amperes-hora)
        - Que serviços usa para carregar o veículo, porquê?
        - Quantos minutos costuma carregar o seu veículo?
            - A que horas?
        - Em que situações costuma carregar o seu veículo?
            - Com que frequência, porquê?
        - Costuma usar Postos de Carregamento Rápido ou Postos de Carregamento Normal?
        - Costuma ou já alguma vez carregou o seu veículo em estabelecimentos comerciais tais como supermercados ou shoppings? Se sim, com que frequência?
        - Que problemas/inconveniências costuma ter no carregamento do seu veículo?
        - O que o deixa mais insatisfeito no carregamento do seu veículo?
        - Que aspetos mais valoriza nos serviços de carregamento elétrico?
        - Gostaria de carregar o seu veículo em estabelecimentos comerciais tais como supermercados ou shoppings? Porquê e que vantagens teria?
        - Imagina um serviço de carregamento de veículos elétricos com parqueamento de um supermercado, que espera de um serviço como este?
            - Que características gostava que o serviço tivesse, (em termos de preço e disponibilidade, por exemplo)?
            - Que vantagens gostaria que este serviço lhe oferecesse para preferir um determinado espaço comercial a outro?

APPENDIX C: Driving EVs and Going to the Supermarket process Interview Guide

- O que faz quando conduz o seu EV? Descreva o processo passo a passo. (Inclua o carregamento do mesmo)
    - Agora, descreva-me brevemente o que sente em cada atividade que definiu na resposta anterior. (Por exemplo, "fico aborrecido, nervoso, contente, eufórico...")

- O que faz quando decide ir ao supermercado? Descreva o processo passo a passo.
    - Agora, descreva-me brevemente o que sente em cada atividade que definiu na resposta anterior. (Por exemplo, "fico aborrecido, nervoso, contente, eufórico...")

APPENDIX D: Bechmarking

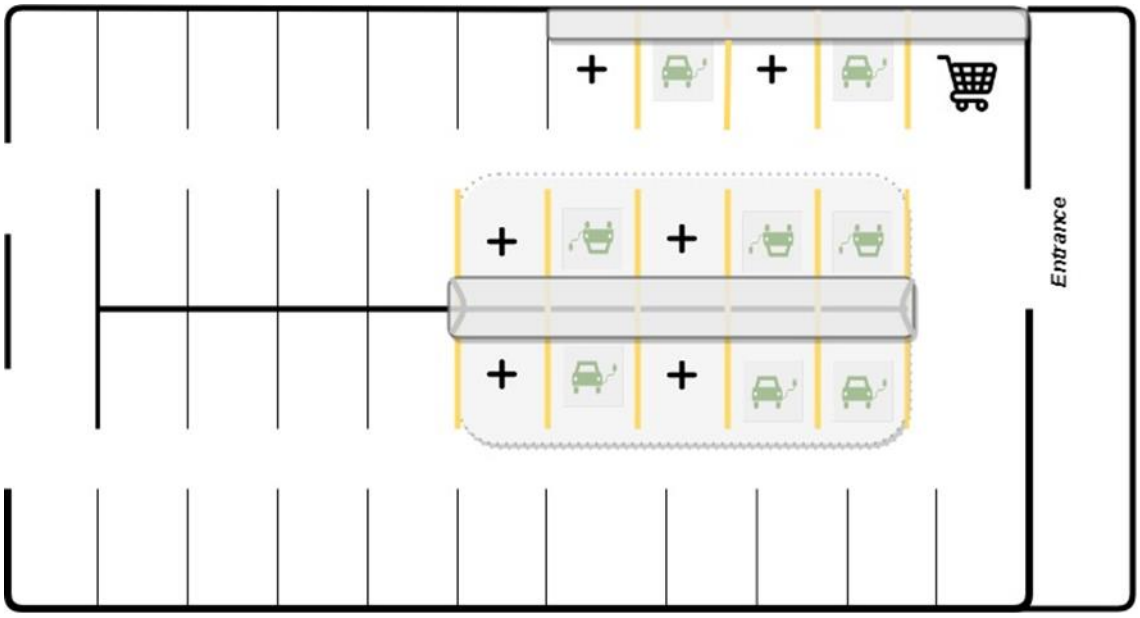
Operator	Location	Town	Number of spots	Type of Charger	Power	Payment Methods	Casback System	Cost
Galp Power	Nova Arcada	Braga	4	TYPE 2 11.00kW	Normal	E-card	Yes	Payed
	Norte Shopping	Matosinhos	4					
	CC Arrábida Shopping	Vila Nova de Gaia	4	Schuko (EU Plug) 2.76kW	Slow			
	CC Gaia Shopping	Vila Nova de Gaia	4	Schuko (EU Plug) 3.68kW Tesla Dest.Charger (Mod S)22.00kW	Slow Fast			
	C.C.Vasco Da Gama	Lisboa	4	Schuko (EU Plug) 2.76kW TYPE 2 11.00kW	Slow Normal			
	Centro Colombro	Lisboa	4	TYPE 2 11.00kW	Normal			

Prio.e	IKEA	Matosinhos	4	TYPE 2 7.40kW	Normal	No	Free
	Mar Shopping	Matosinhos	4	TYPE 2 22.00kW	Normal		
	Alameda Shopping	Porto	2	YPE 2 3.68kW CEE 2P+E (blue - camping) 3.68kW	Slow		
	IKEA	Loures	2	TYPE 2 7.00kW	Slow		
	IKEA	Alfragide	2	TYPE 2 7.40kW	Normal		
	Centro comercial Dolce Vita Tejo	Amadora	2	CEE 2P+E (blue - camping) 3.68kW TYPE 2 3.68kW	Slow		
	IKEA	Loulé	4	TYPE 2 7.40kW	Normal		
KLC	Torres Shopping	Entroncamento	2	TYPE 2 22.00kW	Normal		
	Strada Outlet Shopping	Odivelas	2	TYPE 2 22.00kW	Normal		Payed
	Centro Comercial Fórum	Aveiro	2	TYPE 2 22.00kW	**Normal**		
	Lidl	Cascais	3		fast		
	Lidl	Loures	3		Fast		
	Lidl	Matosinhos	3		fast		
Horizondistance	Braga Parque	Braga	4	TYPE 2 11.00kW	Normal		
Mota-Engil Renewing	Fórum Sintra	Sintra	4	TYPE 2 22.00kW	Normal		Free
	Fórum Almada		4	TYPE 2 21.99kW	Normal		
	Montij	Montijo	2	TYPE 2 21.99kW	Normal		
	Centro comercial Fórum Coimbra	Coimbra	2	TYPE 2 22.00kW	Normal		
Mobi.e	Vila do Conde Fashion Outlet	Vila do Conde	6	Schuko (EU Plug) 3.60kW CEE 3P+N+E (red -	Normal		

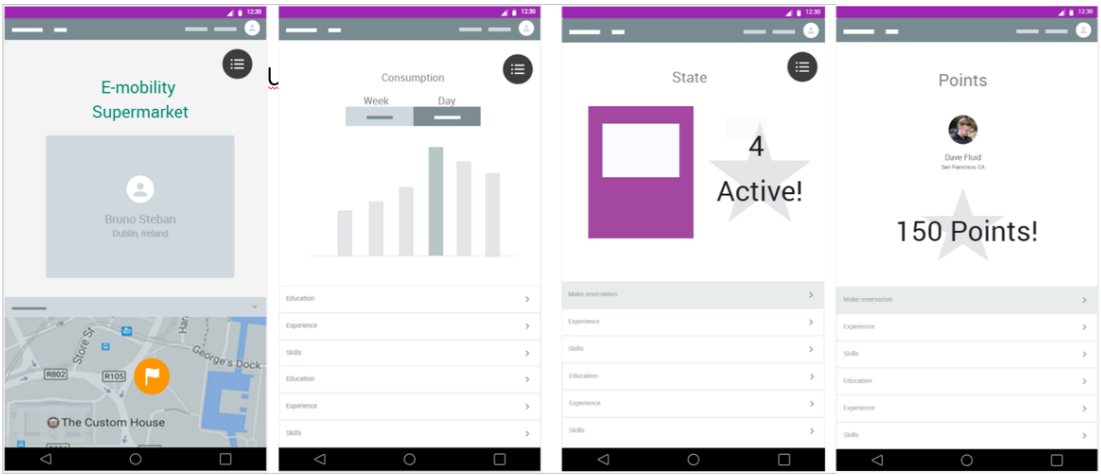
				3-phase)11.00kW TYPE 2 22.00kW		
	Centro Comercial Alegro	Setúbal	2	TYPE 2 3.70kW	Slow	
	Alegro	Alfragide	2	TYPE 2 22.00kW	Normal	
EDP Comercial	W Shopping	Santarém	2	Schuko (EU Plug) 2.76kW	Slow	
Zeev **efacec**	Leroy Merlin	Loulé	4	TYPE 2 22.00kW	Normal	
No Operator	Dolce Vita Douro	Vila Real	1	Schuko (EU Plug) 2.76kW	Slow	No need for card
	Intermarché	Marco de Canaveses	?	TYPE 2 11.00kW		
	Miramaia Shopping	Maia	3	Schuko (EU Plug) 3.60kW CEE 2P+E (blue - camping) 3.60kW CEE 3P+N+E (red - 3-phase)0.00kW		
	Continente Maia Jardim		5	Schuko (EU Plug) 3.68kwW		
	Centro Comercial Parque Nascente	Porto	3	CEE 2P+E (blue - camping) 3.68kW		
	Pingo Doce	Santa Maria da Feira	1	Schuko (EU Plug) 3.68kW		
	Dolce Vita	Ovar	2	Schuko (EU Plug) 3.60kW		
	Leiria Shopping	Leiria	3	CEE 2P+E (blue - camping) 3.70kW CEE 3P+N+E (red - 3-phase)11.00kW Schuko (EU Plug) 3.70kW		

Intermarché	Caldas da Rainha	4	Tesla Dest.Charger (Mod S)22.00kW TYPE 2 22.00kW	Normal
Loureshoping	Loures	2	CEE 2P+E (blue - camping) 3.60kW CEE 3P+N+E (red - 3-phase)11.00kW	Slow and Normal
El Corte Inglês	Lisboa		Schuko (EU Plug) 2.30kW CEE 2P+E (blue - camping) 3.68kW Tesla Dest.Charger (Mod S)21.99kW TYPE 2 21.99kW	Payed parking Slow and Normal
Dolce Vita Miraflores	Algés	2	Schuko (EU Plug) 2.76kW	Slow
Continente de Santo André	Santiago do Cacém	2	TYPE 2 3.68kW	Slow
Aqua	Portimão	3	Schuko (EU Plug) 3.60kW	Slow
Mar Shopping	Loulé	24	Schuko (EU Plug) 0.00kW CEE 3P+N+E (red - 3-phase)11.00kW	Slow and Normal

APPENDIX E: Parking Lot Mock – up



APPENDIX F: Parking E-mobility APP Mock-up



APPENDIX G: Portuguese Entities involved in the Electric Mobility Network

Entity	Description
EMC: Authorization Holders of EM Commercialization	According to the article 7 and 8 of the Decree/Law 39/2010, April 26th, altered by the Decree/Law 90/2014, June 11th, the entity is responsible for wholesaling and retailing of electric energy, to supply the users of an electric vehicle.
DGEG: General Directorate for Energy and Geology	According to the Decree-Law 130/2014, August 29th, altered by the Decree-Law 69/2018, August 27th, has by mission the conception, promotion, availability of policies related to the energy and geologic resources.
EDP Distribuição: Distribution System Operator	This entity holds and manages the operating assets of the distribution network of low and medium voltage. It is responsible for linking all-electric system consuming units and assuring security and reliability of the network in terms of supply of energy for every consumer.
EM service provider	Sells electric mobility services to end customers. These services may include seamless access (without local payment) to various stations of Charging Grid Operators. Also, these services may integrate other complementary services such as parking or locating the vehicle. (Plataforma para o Crescimento Sustentável. 2016)
ERSE: Energy Services Regulatory Authority	Portuguese entity that is responsible for the natural gas, electricity and liquefied petroleum gas sectors. (ERSE. 2015)
Mobi.e SA: Managing Entity of the Electric Mobility Network	According to the terms of the Portuguese article 20 of the Decree-Law 39/2010, April 26th, altered by the Decree-Law 90/2014, June 11th, whose activity consists of the management and monitoring of the electric mobility networkEMN, namely energy, information, and financing flows.
OPC: Operator of Charging Station	According to the Article 14 and 15 of the Decree-Law 39/2010, April 26th, altered by the Decree-Law 90/2014, June 11th, the activity consists on the installation, availability, operation, and monitoring of public and private access infrastructures, integrated into the electric mobility networkEMN and which allow electric vehicles batteries charging.
REN: Portuguese Transmission System Operator	Entity responsible for the supply of energy through a transmission network on a given geographic area (the Transmission Grid). (ERSE. 2015)

EVU: Electric Vehicle User		Customer of the electric mobility network.

APPENDIX H: Portuguese Entities involved in the Electric Mobility Network

Electric vehicle and Charging infrastructure overview

According to Chan and Chau (2001), the electric vehicle is a road vehicle based on modern propulsion which consists of the electric motor, the power converter and energy source. The electric vehicle shall be divided into three categories, taking the power supplement and propulsion devices into consideration. A battery electric vehicle (BEV) can be a Pure electric vehicle (PEV), a Hybrid plug-in vehicle (PHEV) or a Fuel cell electrical vehicle (FCEV). According to Lie et al. (2017), the propulsion of PEV is solely provided by an electric motor. An PHEV combines the electric motor and the engine, as the power sources involve both electricity and gasoline or diesel. An FCEV is driven by an electric motor and could be directly or indirectly powered using hydrogen, methanol, ethanol or gasoline. EVs use a charging infrastructure that can take different traits. In section 2.3 and section 2.4. those traits are explained in detail.

Charging Stations

According to the Decree-Law 39/2010, April 26th, Article 6, CSs are infrastructures dedicated exclusively to the electric vehicle's batteries charge. These are explored by a licensed operator. There are 3 types of CSs:

- Public electric CSs, which are installed on a public place with access to the public via or equated, or at private place that allows access to the public in general. Public CSs are located at municipal ground and publicly accessible. Those always have an individual grid connection and are always operated by an OPC;
- Private access CSs are installed in places of private access;
- Semi-public charging stations are also located at the private ground but are publicly accessible. This type includes, for example, charging stations located at the parking grounds of supermarkets. Semi-public charging stations can be connected to the existing grid connection of the adjacent building or can have an individual grid connection. Since each EV user can charge its vehicle at a semi-public charging station, the object is often operated by an OPC. The operator is the owner of the charging station and charges each EV user for the consumed electricity. Besides that, the operator is responsible for maintaining the charging station (Agência NL, 2010).

Charging power

The European standard IEC 61851, which deals with the charging system, plugs and sockets, provides a first classification of the type of charger in the function of its rated power and so of the time of recharge, defining 3 categories listed above:

- Normal power or slow charging: rated power inferior to 3,7 kW, used for domestic application or for long-time EV parking;
- Medium power or quick charging: rated power from 3,7 to a 22 kW, used for private and public EV;
- High power or fast charging: rated power superior to 22 kW, used for public EV.

According to *Mobi*.e, a PCN takes 6 to 8 hours to fully charge an EV, a PCSR takes 1 hour, approximately, to 80% of capacity and PCRs take 20 to 30 minutes to 80% of capacity.

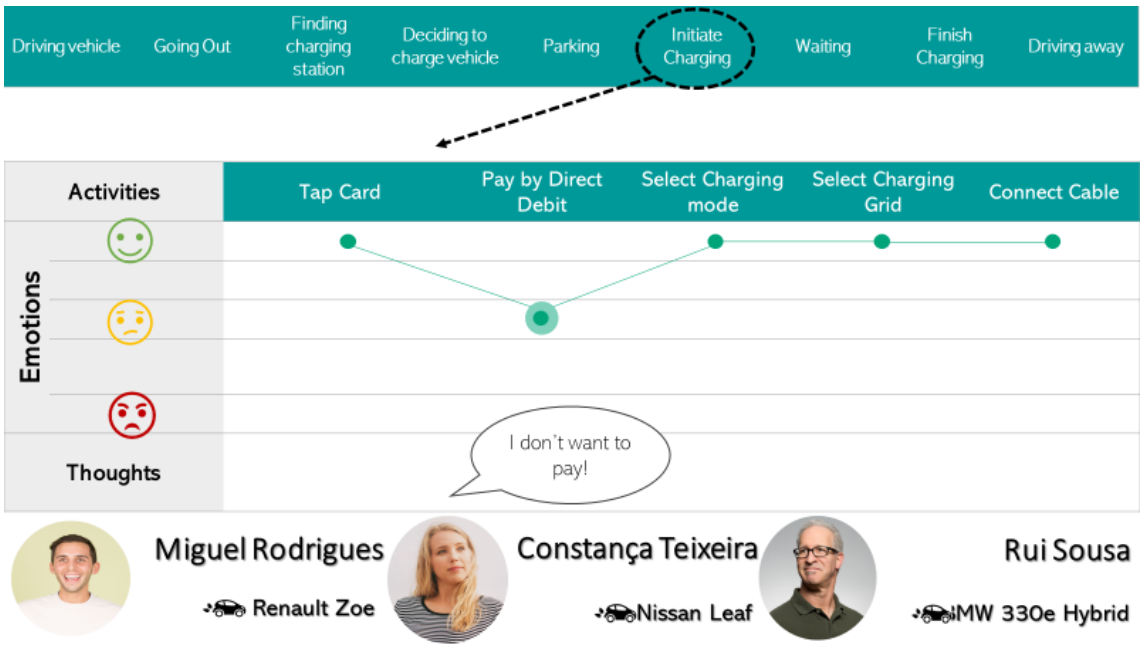
Charging modes

There are 4 different charging modes, from slow charging using a household-type socket-outlet to fast charging using an external charger according to the IEC 62196 standard, which is based on the IEC 61851:

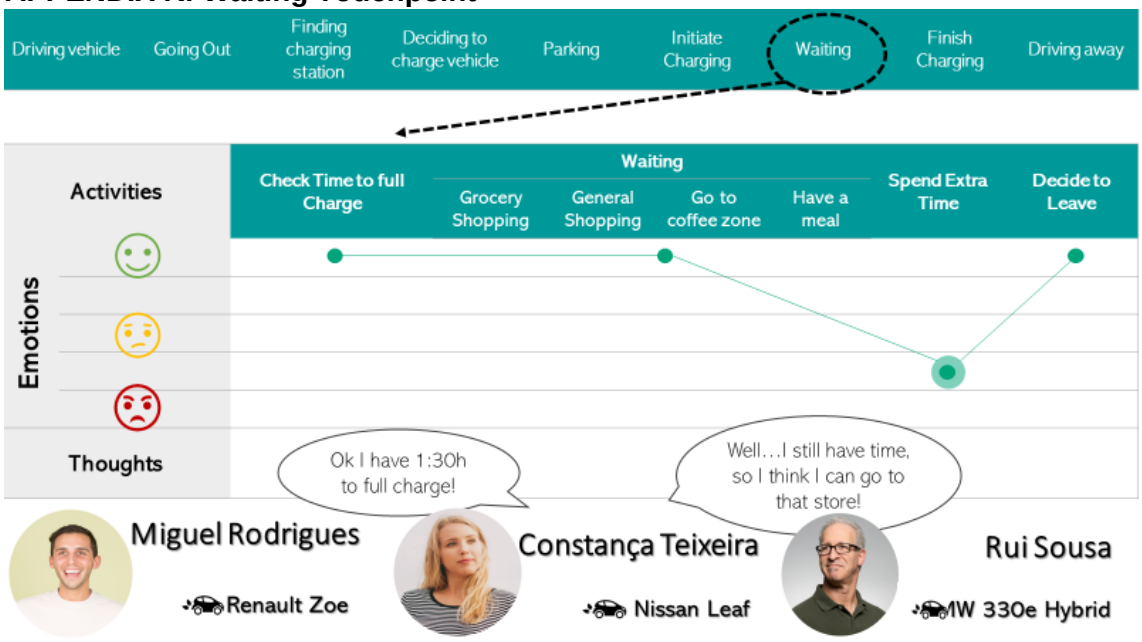
- Mode 1: slow charging from a household-type socket-outlet in Alternating Current (AC). This mode is normally used in motorcycles and similar;
- Mode 2: slow charging from a household-type socket-outlet with an in-cable protection device in AC, normally used in cars;
- Mode 3: slow or fast charging using a specific EV socket-outlet with control and protection function installed in AC, used in Mennekes sockets with a normal charger of an EV;
- Mode 4: fast charging using an external charger in Direct Current (DC), used by a charger that alters the current provided to the vehicle, turning AC to DC.

APPENDIX I: Crossing the experience of going to the supermarket and Charging an electric vehcile

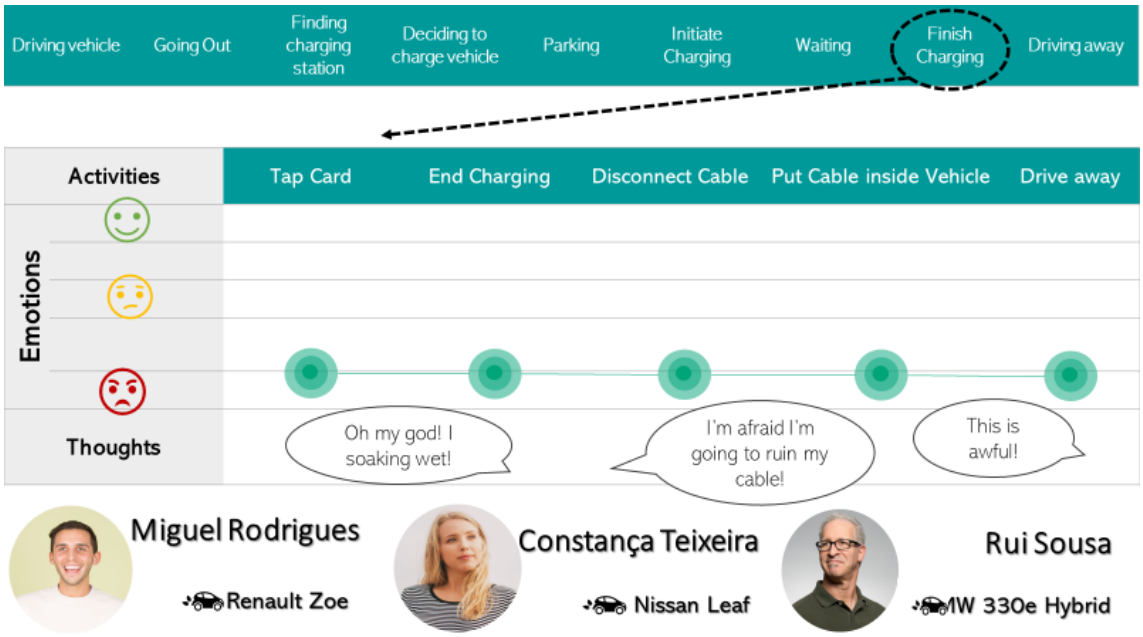
APPENDIX J: Initiate charging Touchpoint



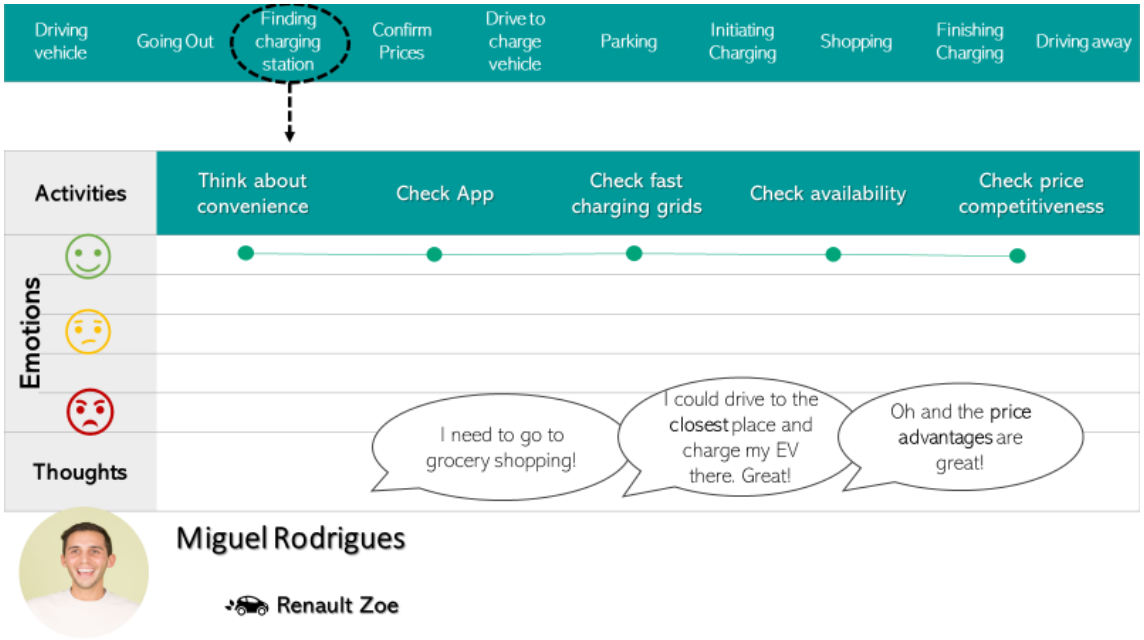
APPENDIX K: Waiting Touchpoint



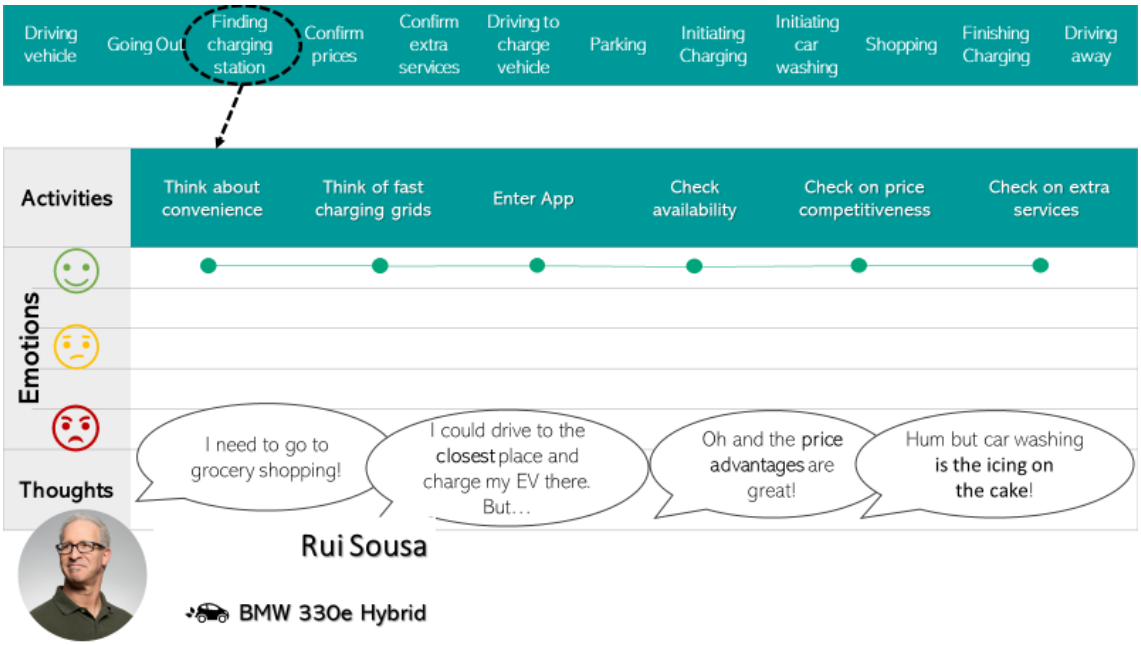
APPENDIX L: Finishing charging Touchpoint



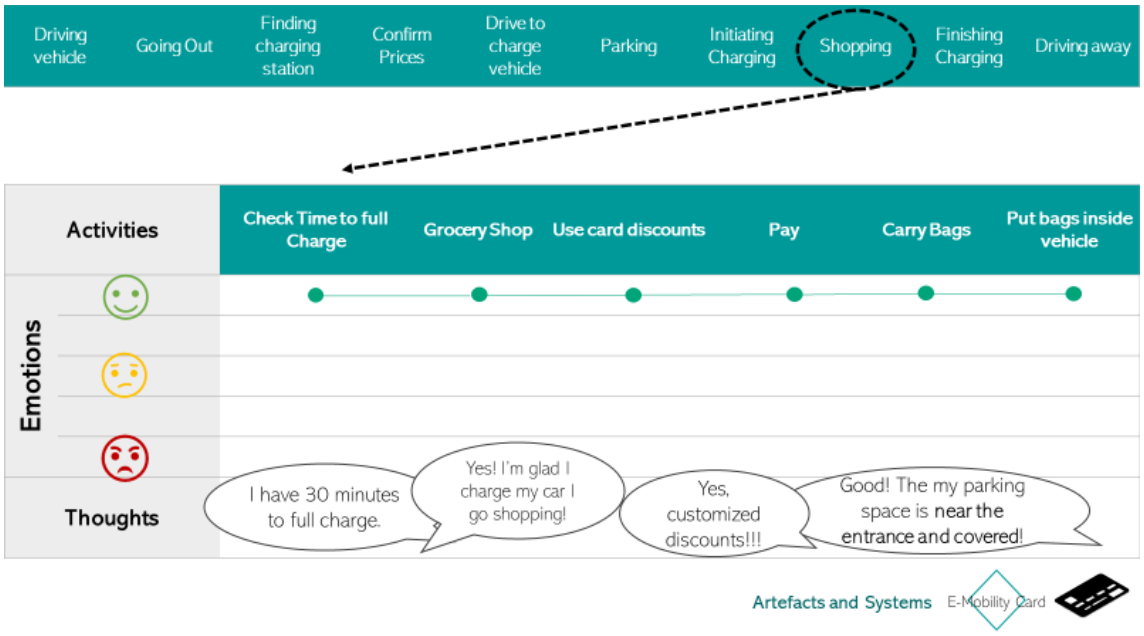
APPENDIX M: Finding Charging Station New Touchpoint by BEV users with home charge



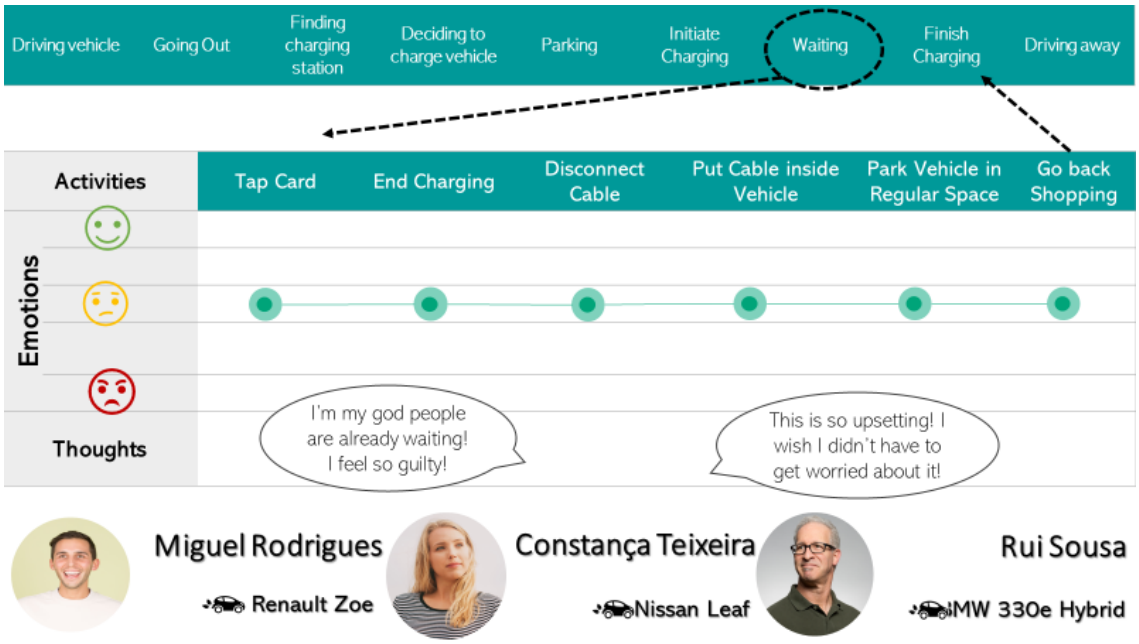
APPENDIX N: Finding Charging Station New Touchpoint by BEV users with home charge



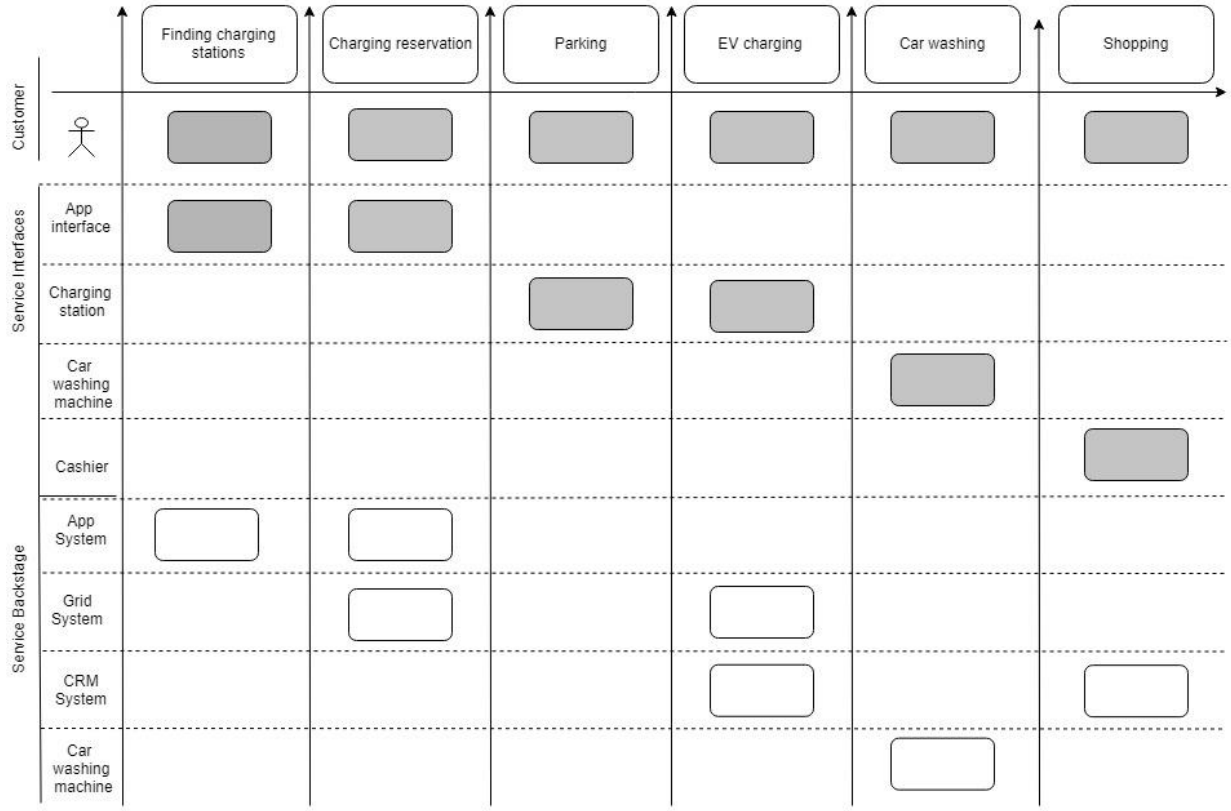
APPENDIX O: Finding Charging Station New Touchpoint by BEV users with home charge



APPENDIX P: Waiting Touchpoint (Do-gooder version)



APPENDIX Q: Service System Architecture



APPENDIX R: Grocery Shopping CVC