AALBORG UNIVERSITY
COPENHAGEN

Semester: CPH SSD 10

Title:

User-centric research & service design to help facilitate electric vehicles (EVs) mass adoption in an urban context

Aalborg Universitet Copenhagen
A.C. Meyers Vænge 15
2450 København SV

Programme coordinator: Luca Simeone

Secretary: Judi Stærk Poulsen

Project Period: Spring semester

Semester Theme: Master thesis

Supervisor(s):

Luca Simeone

Project group no.: N/A

Members:
(do not write CPR.nr.):

Gladys Elisa Chavez

Study no.: 20200752

Pages: 100

Finished: June 30, 2023

Abstract:

Purpose: As was revealed in the literature review more research is lacking in the area of EV users and in the change of interaction between users and this new technology. Thus this thesis seeks to zoom into the user experience of being an EV driver, and to emphatically investigate what this experience is like (i.e., what is working and what could be improved upon) to further facilitate a smoother transition to green mobility that can ensure EVs mass adoption that is necessary to help meet target C02 emission reductions by 2030.
Design/methodology/approach: The Double Diamond methodology was applied to the overall design process – while the 'design thinking process' facilitated complementary stages, or design methods and approaches, undertaken at each phase of the design process.
Findings: Service design's potential at a micro-level has the ability to influence something as complex as the e-mobility transition by applying user-centric and empathic design that helps to lessen the complexity and focuses on zooming-in on the interaction between the user and this new emergent technology and of its service offerings. SD at this level enables keeping the user at center to design a product/service that is truly solving the user's problem and/or addressing the user's needs— in this case helping to address EV users the transition to e-mobility, and with focus on urban dwellers who depend on accessible and reliable on-street charging services for their charging needs.
Research limitations: Investigating the relationship between EV users and this new technology is in its early stages. There is still much uncertainty on how EV charging services should be provided in these early stages of market development (Chavez, 2022; LaMonaca & Ryan, 2022). Furthermore, the transition to electric-mobility is context specific as there will be differences city to city and country to country on what works and what does not. The results of this study may provide a basis for future research on this topic.
Key words: Service design. User-experience. Electric vehicles. Urban e-mobility transition. E-mobility adoption.

When uploading this document to Digital Exam each group member confirms that all have participated equally in the project work and that they collectively are responsible for the content of the project report. Furthermore each group member is liable for that there is no plagiarism in the report.

I. Abstract

Purpose: As was revealed in the literature review more research is lacking in the area of EV users and in the change of interaction between users and this new technology. Thus this thesis seeks to zoom into the user experience of being an EV driver, and to emphatically investigate what this experience is like (i.e., what is working and what could be improved upon) to further facilitate a smoother transition to green mobility that can ensure EVs mass adoption that is necessary to help meet target C02 emission reductions by 2030.

Design/methodology/approach: The Double Diamond methodology was applied to the overall design process – while the 'design thinking process' facilitated complementary stages, or design methods and approaches, undertaken at each phase of the design process.

Findings: Service design's potential at a micro-level has the ability to influence something as complex as the e-mobility transition by applying user-centric and empathic design that helps to lessen the complexity and focuses on zooming-in on the interaction between the user and this new emergent technology and of its service offerings. SD at this level enables keeping the user at center to design a product/service that is truly solving the user's problem and/or addressing the user's needs— in this case helping to address EV users the transition to e-mobility, and with focus on urban dwellers who depend on accessible and reliable on-street charging services for their charging needs.

Research limitations: Investigating the relationship between EV users and this new technology is in its early stages. There is still much uncertainty on how EV charging services should be provided in these early stages of market development (Chavez, 2022; LaMonaca & Ryan, 2022). Furthermore, the transition to electric-mobility is context specific as there will be differences city to city and country to country on what works and what does not. The results of this study may provide a basis for future research on this topic.

Key words: Service design. User-experience. Electric vehicles. Urban e-mobility transition. E-mobility adoption.

II. Acknowledgements

First and foremost, I would like to express my gratitude to my supervisor Luca for his constant and consistent support and guidance throughout this thesis process—and for the trust and confidence he has had in my capabilities to deliver this thesis. Your support and feedback has been inspiring and reassuring throughout the entire process. Thank you for having faith in me.

Secondly, I would like to thank all the participants that provided their invaluable time and input in partaking in the online survey—and for all those within my personal and professional network who helped to extend the reach of the survey by sharing it through their networks. And to the willing

participants that chose to contact me after finding a flyer on their vehicle to partake in my user research interviews to better understand their personal experiences as EV users—I deeply appreciate their willing support to contribute to this research, and to my surprise, without requiring the included gift certificate incentive for their willing participation.

Thirdly, I would like to thank the support of my SPS counsellor Mie in helping me to manage my *Attention Deficit Hyper Disorder* (ADHD) and depression—and to help me find and to strategize sustainable and healthy ways of working, that always kept my health and wellbeing at forefront. To my assigned SPS PhD candidate tutor Nanna, who also provided me with great advice and guidance on how to tackle this thesis one piece at a time by providing me with suggestions on pragmatic approaches to ensure I could meet the final deliverable deadline. And to my dear, great friend Astrid who has been an amazing support—constantly being present for me, supporting me along the way, and helping me with her invaluable user experience (UX) and graphic design expertise.

Lastly, I would like to express my greatest gratitude to my husband Nicolas who has supported me through this entire journey and has been a rock to me the entire way—not only by always being by my side and always encouraging me, but also by being an active participant while I undertook field research, in the ideation phase and in helping to review and comment on my work throughout the entire thesis process. I could not have done this without your constant and loving support and belief in me!

III. Abbreviations

SD: service design
E-mobility: electric mobility
CI: charging infrastructure
CS: charging stations
CP: charge point
EV: electric vehicle
PHEV: plug-in hybrid electric vehicle
CPS: charge point service (providers)
ICE: internal combustion engine (vehicle)
PPP: public private partnerships

IV. Interchangeable words

– Users, consumers and drivers (and referring to private individuals)

– EV will be used to refer to both plug-in electric vehicles and to hybrids which will be further elaborated upon in section 1.1.

V. Table of figures

VI. Table of contents

1 Introduction (Chavez, 2022)

Climate change is undoubtedly one of the biggest challenges of our times, and the reduction of greenhouse gas emissions is crucial for Earth's and all its inhabitants' survival (Egnér & Trosvik, 2018; The Economist, 2022). However, even though the world's countries have pledged to steeper reduction of emissions these pledges still fall short of what is needed to keep rising global temperatures below 2 degrees Celsius (The Economist, 2022). The transportation sector is responsible for large amounts of CO2 emissions with cities being responsible for nearly 80% of carbon emissions (Haddadian et al., 2015; Kneeshaw, 2012).

Taking into account the urgent need for action on climate change "*cities, businesses and governments all over the world*" acknowledge that electric vehicles (EVs) are a key contributor to environmental sustainability by helping to reduce resource scarcity and environmental decline (Boucetta et al., 2021; Haddadian et al., 2015, p. 53). According to many scholars, EVs are a ground-breaking substitute to internal combustion engine (ICE) vehicles with the ability to make city streets cleaner by improving air quality via the decrease

of CO2 emissions, and quieter by reducing the noise normally generated by ICE vehicles (Kneeshaw, 2012; Pardo-Bosch et al., 2021).

Many countries have set ambitious targets to improve the EV market share, however despite promotion strategies for EV adoption evidence from various countries reveals that adoption remains slow as governments have been lacking to address all market segments (i.e., the mass market) – especially in an urban context for drivers relying on-street parking (Banjarey et al., 2021; Trip et al., 2019). So far EVs have been confined to niche market segments of affluent consumers with private home parking, or to fleet operators (public or private)(Trip et al., 2019). But for EVs to move out of the top tier niche market and to reach the masses, those with on-street parking must be taken into account to enable EVs mass adoption (Trip et al., 2019; Wolbertus et al., 2018).

The transformation of the transportation sector to e-mobility is without a doubt one of the most momentous transformations of our times, and one that will necessitate many disciplines involved in its facilitation (Kneeshaw, 2012; Haddadian, et al., 2015).

1.1 Electric vehicles background (Chavez, 2022)

EV refers to any vehicle in which some or all energy for operating the vehicle is supplied by electricity from the car's battery such as: *battery-electric-vehicles* (BEVs); *plug-in electric vehicles* (PEVs); and *plug-in hybrid electric vehicles* (PHEVs) . A BEV or PEV utilizes only an electric battery powered motor to operate, and this battery is charged via a charging infrastructure (CI) point that connects to the energy grid. A hybrid on the other hand (i.e., PHEV) utilizes an electric powered engine, but when the battery runs out of energy the vehicle switches to an internal combustion engine, as those found in ICE vehicles (Shen et al., 2019).

The EV industry itself is the merging of two formally different sectors—the transport and energy sectors, and as a result currently with fewer regulations and constraints (Banjarey et al., 2021; Yang et al., 2016). The main stakeholders that comprise this emergent industry can be divided into three clusters: 1.) **EV service providers** (such as *utilities and charging infrastructure*) 2.) **EV service operations** (such as EV business models, infrastructure planning, EV charging operations and public policy) and 3.) **EV adopters** (such as *private car owners, private fleet operators and public fleet operators*). These three clusters all operate under the umbrella of the government (Shen, et al., 2019).

1.2 Motivation

During the preliminary inquiry to this thesis, a traditional narrative review was conducted to investigate if, and if so, how *service systems design* (SSD) could facilitate EVs mass adoption in an urban context. The findings in the review explored key barriers and opportunities to EVs mass urban

adoption—and in how SSD could potentially assist in lowering these barriers by leveraging the opportunities. In the conclusion of the review various possible future research directions were addressed for further exploration. Of these possible future research directions, the motivation for this thesis is to zoom in and examine the *service interaction perspective* of the value-creation process, as service design must take into account the changes in interaction between users and of electric vehicles (EVs) (Morelli et al., 2021; Silvester et al., 2013) such as with *users charging behavior*— of *group specific needs* such as that of urban dwellers who rely on on-street CI—and on how charging services should be provided as there is still much uncertainty in these early stages of market development (Chavez, 2022; LaMonaca & Ryan, 2022). As was revealed in the literature review more research is lacking in the area of EV users and in the change of interaction between users and this new technology. Thus this thesis seeks to zoom into the user experience of being an EV driver, and to emphatically investigate what this experience is like (i.e., what is working and what could be improved upon) to further facilitate a smoother transition to green mobility that can ensure EVs mass adoption that is necessary to help meet target C02 emission reductions by 2030.

1.3 Learning objectives

The official learning objectives for this thesis are defined by Aalborg University as competences, skills and knowledge the service systems designer must obtain at the completion of this Master's program. The personal learning objectives are a reflection personal intentions and of research curiosities/objectives, while embarking on thesis process and for its final deliverable.

1.3.1 Official learning objectives (AAU, 2020)

Knowledge

Students who complete the module will obtain the following qualifications:

– Must have knowledge about the possibilities to apply appropriate methodological approaches to specific study areas.
– Must have knowledge about design theories and methods that focus on the design of advanced and complex product-service systems.

Skills

Students who complete the module will obtain the following qualifications:

– Must be able to work independently, to identify major problem areas (analysis) and adequately address problems and opportunities (synthesis).
– Must demonstrate the capability of analyzing, designing and representing innovative solutions.

– Must demonstrate the ability to evaluate and address (synthesis) major organizational and business issues emerging in the design of a product-service system.

Competences

Students who complete the module will obtain the following qualifications:

– Must be able to master design and development work in situations that are complex, unpredictable and require new solutions (synthesis).
– Must be able to independently initiate and implement discipline-specific and interdisciplinary cooperation and assume professional responsibility (synthesis).
– Must have the capability to independently take responsibility for own professional development and specialization (synthesis).

1.3.2 Personal learning objectives

– To gain more theoretical knowledge and practical experience of zooming-in and working with *service as an interaction* (Morelli et al., 2021) with focus on the user experience (UX).
– To practice self-care and mindfulness—staying open, curious and to enjoy the thesis process in its exploration, learning and application of different service design tools and methods.
– To hopefully find a feasible service solution that can address current user pain points in transitioning from internal-combustion engine (ICE) vehicles to EVs— a solution which could further facilitate the successful EV mass adoption in an urban context.
– To hopefully inspire further EV user research, and on how charging services should be provided as there is still much uncertainty in these early stages of market development (LaMonaca & Ryan, 2022; Chavez, 2022).

1.4 Reading guide

This reading guide provides an overview of the thesis chapters.

Chapter 2: Related works

Chapter 2 presents a summary of key insights from a preliminary inquiry literature review—and with a brief overview of service design as a discipline, of its fundamentals and its potential to facilitate EV adoption. Followed by the project context and academic research question.

Chapter 3: Research methodology

Chapter 3 presents the design methodologies that were employed to explore and aim to answer the research question. The chapter summarizes with a visual representation of the overall design research process.

Chapter 4: Design process

Chapter 4 the design process is organized following the Double Diamond's framework divided into sections based on the four Double Diamond phases—discover, define, develop and deliver. This chapter documents the entire service design process that was undertaken from user-centered problems that were identified during the research to finding a viable service design solution to address these.

Chapter 5: Discussion

Chapter 5 discusses the academic research questions based on key findings and reflections upon the design process—and the academic and personal learning objectives.

Chapter 6: Conclusion

Chapter 4 concludes on the key findings related to the academic research question. Additionally, it presents the limitations of this study and possible areas of future research.

2 Related works

This chapter presents a summary of key insights from the preliminary inquiry review—and with a brief overview of service design as a discipline, of its fundamentals and potential to facilitate EV adoption. Followed by the project context and academic research question.

The chapter is divided into the following subchapters:

2.1 Preliminary inquiry

As aforementioned in the introduction, prior to commencing the design process for the thesis, a preliminary inquiry was conducted via a 'traditional narrative review'. The preliminary inquiry involved searching for and evaluating relevant peer-reviewed (and gray literature) with focus on if, and if so, how *service systems design* could facilitate electric vehicles (EVs) mass adoption in an urban context.

It should be noted that the preliminary inquiry review started off as a semester project for the 9th semester of the Master's, and it was delivered based on a total of 20 reviewed articles. Thus at the

start of 10th semester, the literature review was expanded to now include an additional 24 reviewed articles. Furthermore, the writing of the review was expanded upon as well based on the additionally reviewed articles. This expanded literature is included in this exam hand-in.

In order to facilitate context (or a red thread) in the reading of the thesis, below are the expanded review's key findings to barriers and opportunities to EVs mass urban adoption in an urban context.

2.1.1 Key barriers (Chavez, 2022, p. 14-22)

Lack of public EV charging infrastructure

EV technology has only continued to improve with, for example, car batteries that are now more efficient allowing for longer driving distances and with faster charging capabilities (Trip et al., 2019). Yet one key barrier remains at the forefront that is hindering the mass adoption of EVs— the lack of public charging infrastructure (CI) whose development is key to EVs continued market growth (Anthopoulos & Kolovou, 2021; Banjarey et al., 2021; Kongklaew et al., 2021; Shi et al., 2021) […] EVs require adequate CI but presently there exists a lack of publicly available charging stations (CS') which restricts the ability for drivers to take longer trips, thus limiting the utility and attractiveness of having an EV (D. Hall & Lutsey, 2017; Luo & Qiu, 2020; Silvester et al., 2013; Trip et al., 2019). Supporting CI is deemed a *critical success factor* to the mass adoption of EVs as CI is the *supporting service* necessary for the *basic functionality* of EVs thereby enhancing consumer confidence in EV technology (Adhikari et al., 2020; Bakker & Jacob Trip, 2013; Maia et al., 2015) […] This is especially the case for urban dwellers in areas where dedicated parking facilities are limited, or nil, and with very few EV owners having access to private home charging accessibility—thereby having to solely rely on public CI for their charging needs (Berkeley et al., 2017; Burkert et al., 2021; Calearo et al., 2021; D. Hall & Lutsey, 2017; Pardo-Bosch et al., 2021; Shi et al., 2021; Wolbertus et al., 2018).

'Range anxiety'

Various studies have shown 'range anxiety' to be a major barrier to EV adoption. Range anxiety describes drivers stress regarding the available battery range while driving an EV, as with 'range anxiety' EV users psychologically fear being left stranded with empty batteries (Broadbent et al., 2018; Elkind, 2017; Salah & Kama, 2017; Trip et al., 2019). 'Range anxiety' is highly discouraging to potential EV consumers due to the lack of public CI—particularly crucial in dense cities where at-home charging is not a feasible, or an available option (He et al., 2022).

Lacking interoperability between CI/CS networks

Since the EV market is in its early stages of development there is vast uncertainty on how EV charging services ought to be delivered, as well as which policies are best to implement for continued development (LaMonaca & Ryan, 2022). EV refueling lacks considerably to ICE vehicles in charging methods and types of accessibility (Anthopoulos & Kolovou, 2021). Currently despite all technological EV improvements since entering the market, existing CI/CS' networks still suffer from fragmented information, unreliable data availability and with missing standards and regulations amongst the networks (Broadbent et al., 2018; Hall & Lutsey, 2017; Salah & Kama, 2017; Trip et al., 2019). At the moment there is no direct communication available between CI/CS networks "*resulting in isolated networks where users cannot cross-network CS facilities"* (Sahala and Kama, 2017, p. 157). CI/CS' networks remain linked to various types of payment methods via a large number of small *charge point service* (CPS) providers who all have different *accessibility and payment* methods for their charging services (Burkert et al., 2021).

Significance of access mode

Improvements in interoperability are urgently needed as the availability and accessibility of CS networks is important to relieving aforementioned 'range anxiety'—thus highlighting the importance that besides requiring available CI/CS networks, users need accessibility to them all (Broadbent et al., 2018; Salah & Kama, 2017). Interoperability ensures that EV drivers can travel as they would with ICE vehicles by having the ability to refuel at any CI/CS network provider, thereby facilitating for EVs to be a closer substitute to ICE vehicles in re-fueling and payment convenience, accessibility, and user-friendliness (Broadbent et al., 2018; Falchetta & Noussan, 2021; Salah & Kama, 2017).

Lacking or poor policies, regulations and incentives

Numerous initiatives for e-mobility are being supported by governments, companies, universities and private individuals but as a key barrier many of these activities are not well-aligned (Trip et al., 2019). For example, a lack of public CI policies—such as for interoperability—are not ensuring EVs can be a closer substitute to ICE vehicles (Egnér & Trosvik, 2018). For example, *charging behavior control policy* is a key issue to address as e-mobility requires changes in user behavior (i.e., switching from ICE vehicles to EVs way of charging) (Berkeley et al., 2017; Silvester et al., 2013; van der Kam et al., 2020; Wicki et al., 2022; Wolbertus et al., 2018). For example, Wolbertus et al. (2018) explored different policies for dense urban areas where there is lots of on-street parking and with high parking pressure and found that free parking policies for EVs have become problematic when EV owners (with at home charging capability) use the charging spots for free city parking—and additionally EV

users have no reason to remove their EVs from charging points after the completion of the charging process—which is a challenge in busy urban areas (Burkert et al., 2021).

2.1.2 Key opportunities

Multi-stakeholder collaboration

Due to the complexity of the EV ecosystem—such as with development of its public charging infrastructure—the EV transition necessitates multiple disciplines (Berkeley et al., 2017; Geronikolos & Potoglou, 2021; D. Hall, 2017; Kneeshaw, 2012; Kongklaew et al., 2021; LaMonaca & Ryan, 2022; Silvester et al., 2013). For example, big cities face challenges allocating reserved spaces for EV parking and charging points in busy urban areas— so identifying public CI locations is a complex task and it is important to bring in all relevant stakeholders (e.g., city hall officials, energy companies, grid operators, IC installers, etc.) to engage in multidisciplinary collaboration (Berkeley et al., 2017; D. Hall, 2017; D. Hall & Lutsey, 2017; Kneeshaw, 2012). Globally this has been observed to be the most effective means for the deployment and implementation of public CI/CS networks in leading EV markets (Hall & Lutsey, 2018). Since transport is a public establishment it affects a broad range of interests from people and organizations—and e-mobility, being a disruptive and emergent transport system, requires the engagement of a diverse set of stakeholders to partake in a broad discussion about the societal implications of the EV transition as it requires both cultural and infrastructural change (Maia et al., 2015). Silvester et al. (2012) found that designers of these new e-mobility concepts must reflect on the cultural trends of these new mobility patterns, working together with multi-disciplinary backgrounds such as those of architecture, urbanism, industrial design and energy engineering—as well as with municipalities, traffic police, power companies and other government departments (Silvester et al., 2013; Yang et al., 2016). Trip et al. (2019) further elaborate that to effectively implement e-mobility it is key to involve various stakeholder groups that also include knowledge institutions, fleet operators and especially private EV consumers, as their interests are key to EVs successful mass adoption.

Government's effective policies, regulations & incentives

Government plays a key role in the development of the public CI network, and for this development to occur support policies are necessary to create a stable foundation for further market expansion (Falchetta & Noussan, 2021; Kneeshaw, 2012; Pardo-Bosch et al., 2021; Trip et al., 2019). Targeted policy measures for public CI have been found to be the most effective means to increasing EVs mass adoption (Anderson, 2019; Bakker et al., 2014; Bakker & Jacob Trip, 2013; Banjarey et al., 2021; Broadbent et al., 2018; Calearo et al., 2021; Falchetta & Noussan, 2021; D. Hall & Lutsey, 2017; Santos & Davies, 2020; Sierzchula et al., 2014; Trip et al., 2019; Van der Steen et al., 2015; Wolbertus et al., 2018). Banjarey et al. (2021) reviewed the EV policies of various countries, via an in-depth study on EV adoption

policies, and found that since public CI is crucial to accelerate EV adoption the role of government is key to facilitating EVs acceptance and deployment as well as to building the EV ecosystem. But as aforementioned, policymakers in urban cities with street parking face a dilemma on how to organize public CI effectively—thus Wolbertus et al. (2018) addressed how governments must facilitate public charging networks taking into account *design policies* for optimizing the use of public CI/CS networks, and their effects on adoption (with focus on urban EV owners with public charging as a dominant mode). The findings revealed that *charging behavior control policies* are key, especially in busy urban areas with on-street parking and with lots of parking pressure (ibid)**.** What is more, Trip et al. (2019) found that to effectively implement e-mobility, it is key to apply a *synchronized comprehensive approach* to policies (involving various stakeholders groups) as with the typical *transition policy* municipalities try to cope with the interests of various different stakeholder groups—including non-EV drivers who too want to have a stake on the developments in their neighborhoods (Bakker et al., 2014; Trip et al., 2019; Wolbertus et al., 2018). And for the development and deployment of public CI, public support is inevitably needed (Bakker et al., 2014). Furthermore, Silvester et al. (2012) explored how municipalities could install public CI in a way that is viable and socially inclusive directly benefiting both EV drivers by having more spaces to park and charge—and indirectly benefiting all citizens from the reduction of both air pollution and the reduction of the noise generated by ICE vehicles. But, again, municipalities must ensure citizen buy-in as well as political support (LaMonaca & Ryan, 2022; Pardo-Bosch et al., 2021).

Thus far, various governments have created programs for the construction of CI through *incentives, regulations and partnerships* (D. Hall & Lutsey, 2017; Sierzchula et al., 2014). The most pro-active cities, that wish to stimulate EV uptake, adopt various policy measures such as: investment in a large number of on-street CI/CS networks; incentives for business and individual EV owners (e.g., with financial support to install charging points); *public-private partnership*s (PPPs) to purchase and install equipment and to reduce investment risks; parking policies so parking spots are not monopolized by fully charged EVs, or taken up by ICE vehicles; and regulatory measures to obligate property developers to include visible and convenient CI in 10-20% of parking facilities in apartments/condominiums, offices and within activity areas such as shopping centers thereby making EVs more compatible to drivers' daily lives (Bakker & Trip, 2013; Broadbent et al., 2018; Hall, 2017; Hall & Lutsey, 2017; He et al., 2022; LaMonaca & Ryan, 2022; Rezvani et al., 2015). Furthermore, many cities create programs to specifically target drivers relying on on-street parking in city areas where the potential charging demand is high (Bakker & Trip, 2013; Elkind, 2017). Leading governments have created and provided programs that target different market segments, and programs which are transparent and easily accessible for EV drivers and to all industry stakeholders (D. Hall & Lutsey, 2017).

Innovative business models & *Public-private partnerships* (PPPs)

The current business model for EVs is not sustainable for the development of public CI due to the private sectors reluctance to invest until more EVs are on the road, while at the same time consumers are averse to adopting EVs until there is sufficient public CI available to meet their charging needs— the *Chicken and Egg dilemma* (Wolbertus, et al., 2018). Various studies agree that *innovative business models* can help to address lack of public CI, and its resultant *'range anxiety'*, by providing novel solutions that can create and capture EVs values thereby facilitating a smoother transition to EV mass urban adoption (Anthopoulos & Kolovou, 2021; Bakker & Jacob Trip, 2013; Berkeley et al., 2017; Haddadian et al., 2015; D. Hall, 2017; D. Hall & Lutsey, 2017; Kneeshaw, 2012; Köksal, 2021; Kongklaew et al., 2021; LaMonaca & Ryan, 2022; Pardo-Bosch et al., 2021; Salah & Kama, 2017; van der Kam et al., 2020; Wolbertus et al., 2018). New e-mobility business models can link three important sectors that were previously isolated from each other: *original equipment manufacturer* (OEM) industry, energy systems and transport infrastructure (S. Hall et al., 2016). With innovative business models ``*cities can capitalize on governance roles and build on* […] *existing relationships with EV stakeholders such as utility companies, grid operators, citizen and consumer groups, business support agencies, research institutes, vehicle suppliers and universities"* (Kneeshaw, 2012, pp. 4). The EV ecosystem necessitates new and innovative business models to facilitate the vital changes necessary for the development of public CI— as well as for e-mobility services, to market effectively and to change travel behavior (Haddadian, et al., 2015; Rezvani et al., 2015; Bakker & Trip, 2013; Kneeshaw, 2012).

The conditions for successful innovation are to stimulate co-creation in multi-stakeholder collaboration (across the private, public and non-profit sectors) to share risks and gains, and to open and share knowledge of successes and failures—and this innovation relates not only to EV technology but to the processes such as forming partnerships, models of finance and e-mobility services (S. Hall et al., 2016; Kneeshaw, 2012; LaMonaca & Ryan, 2022). But governments must step in to facilitate this new network configuration to enable a way to sustainably support this transition both for the private sector and for civil society (Wolbertus, et al., 2018). Here, Yang et al. (2016) and Wang and Ke (2018) found that *public-private partnerships* (PPPs) are an effective way to accelerate the development of public CI as PPPs offer a way to access the private sector's resources and professional skills, while easing the burden for municipalities. PPPs enable achieving a 'win-win' situation by facilitating the purchase and installation of public CI equipment, where the public and private sectors can share both risks and costs and thereby enhance mutual project management and profitability (Hall, 2017; Kneeshaw, 2012). For instance, for several years governments and private firms have been building infrastructure with many countries in the EU having established PPPs to increase public CI (Banjarey, et al., 2021). Governments are in a position to actively facilitate PPPs, and will continue to play a crucial role, as their participation *reduces perceived risk of intervention* and thus provides security to private sector actors (Silverster, et al., 2013; Hall & Lutsey, 2018). Furthermore, collaboration with entrepreneurs, investors, researchers, financiers and banks has been found to be a promising way to succeed (Kneeshaw, 2012).

2.2 Service design

In definition "service is a time perishable, intangible experience performed for a customer acting in a role of co-producer" (Fitzsimmons, 2014) Services are human-centered and are relational and social in nature – as well as temporal as they happen over time and space and are based on interactions (i.e., the service encounters)(Kimbell, 2009; Penin, 2019). Depending on the nature of the service, that interaction—or what the designers call "touchpoints"—could be in a range such as with printed materials, customer service call centers, digital websites or apps, and/or with service personnel (Kimbell, 2009). And these encounters could take place at a customer's own home or office, or other at locations such as on the street when parking an EV to plug into charging service infrastructure (ibid).

Services have been designed without service designers for decades (Manzini, 2015) but the emergence of service design as a "stand-alone" profession is fairly recent founded on knowledge originating from distinct areas of service management studies and from services marketing (Fitzsimmons, 2014; Kimbell, 2009; Wilson, 2016). It is an emergent profession (Kimbell, 2009) rooted in 'design thinking', with a human-centered approach to designing services through collaborative methods (Stickdorn et al., 2018, p. 20). Service design is an explorative and multidisciplinary practice that involves working with diverse stakeholders to create new forms of value creation (Kimbell 2009 as cited by Manzini, 2015. P. 38). It is a design-driven practice that applies the tangible practices of design with strategic and systems based approaches (Penin, 2018 as cited by Peruccon, 2021) —designing from the micro level of user-centric interactions to the macro level of the configuration of ecosystems that connect diverse networks of stakeholders (Morelli et al., 2021; Peruccon, 2021; Stickdorn & Schneider, 2018; Vink et al., 2017).

Service design is often described as a user-centered, iterative and creative process that prompts service innovation (Stickdorn & Schneider, 2018). SD focuses on creating and/or improving services to deliver better user experiences and outcomes. This involves understanding the needs, desires and behaviors of users—as well as considering the various touchpoints, interactions and processes that make up a service experience (ibid). Here service designers apply design thinking principles and methods to analyze, visualize and innovate (or to improve) services.

SD as a practice is based on the following *service design* fundamentals (below table 3).

Service Design as a practice is based on the following fundamentals :

*(1) It is **user-centric***	The end-user's perspective is at center of the design. Service designers must have a deep understanding of users' needs, motivations and pain points. This can be achieved by employing various research methods such as field research observations, interviews and user testing in order to gain insights. Here empathy is a key capability as it requires having the capacity to understand user feelings, thoughts and individual experiences (i.e., to put yourself in users' shoes) (*Build an Empathy Map | Coursera*, n.d.-a; Stickdorn & Schneider, 2012).
*(2) It is **co-creative***	In the process of designing (or redesigning) a service the value of having users and stakeholders engaged in the design process is co-creative (ibid, p. 31). It is a creative, human-centered process achieved through collaborative methods that enable holistic and meaningful improvements (Chavez, 2022; M. Stickdorn & Schneider, 2018, p. 20). The service designer's key task is to facilitate this process by including different stakeholders in the design process in order to enable value creation for all actors within a given service system (Stickdorn & Schneider, 2018, p. 30).
*(3) It is **sequential***	By applying tools such as user journey maps service designers can visualize the end-to-end user experience to identify touchpoints and to better understand user emotions and interactions throughout the entire user journey (pre-, during and post- a service experience) (Stickdorn & Schneider, 2012).
*(4) Key to **evidencing** services*	Since services are intangible as they cannot be *seen, smelled, tasted or touched* (Fitzsimmons, 2014) SD is key to making services tangible via *physical evidence* such as with "the tangible application of prototypes, immersive experiences and/or scenarios" (Chavez, 2021, p. 6). For example, service designers develop prototypes, both physical and/or digital, to test and iterate service concepts.
*(5)It is **holistic***	Service designers hone in on the experience of all stakeholders engaging with a service—zooming in and out on a micro-, meso-, and macro-perspective to consider the service in fine-grained detail and to zoom out and consider the service as a whole (i.e., *to see the forest for the trees*) (Kimbell, 2009). Service designers consider the entire ecosystem to analyze the dependencies, interactions and interrelationships between different stakeholders, systems and touchpoints. Here service designers can identify opportunities for service innovation such as by exploring

	new business models and value propositions to enhance the overall service experience. Viewing the service in a holistic manner enables service designers to understand all aspects of a service and to how it is perceived by the user (Stickdorn and Schneider, 2012, p. 38).
*(6) Is **iterative***	Service designers embrace an iterative approach, continuously learning, testing and refining service concepts.

Table 1— Service Design Fundamentals (Stickdorn and Scheneider,, 2012; Stickdorn and Scheneider, 2018)

2.3 Service design (SD) as a facilitator to EV adoption

"Service design has the potential to inspire social and cultural transformation, to reshape business and industrial processes. It plays an important role in how the world can innovate more sustainably, especially due to its human-centered viewpoint. […] Design, as a problem-solving discipline, can be used as a tool to stimulate the necessary innovation that deals with a large number of human-related constraints" such as with EV mass adoption in an urban context (Fleischmann, 2020, p. 1). Service designers are more and more involved in devising service concepts around products, such as EVs, with the potential to facilitate the adoption of such products by applying a user-centric perspective aimed at delivering better user experiences and outcomes (Ceschin & Gaziulusoy, 2016, p. 131).

2.4 Project context

A few years ago Denmark's government understood that Denmark's roads need to become greener in order to meet its ambitions to reach CO2 emissions reduction goals by 2025 and 2030 (TV 2, n.d.). But the Climate Council has assessed that the government's action plan is not currently meeting the expected CO2 reductions needed to meet its ambitions (*The Climate Council*, n.d.). To facilitate the green transition, the transport sector is central to decreasing CO2 emissions where electric mobility (e-mobility) is a key focus and central solution (*The International*, n.d.). However, this requires increasing the number of charging infrastructure, and of its service offerings (ibid)—especially crucial to vehicle owners living in multi-unit dwellings, without at-home charging accessibility thus having to rely solely on on-street charging services.

In latest available statistics 46% of Copenhageners reside in multi-unit dwellings (*Statistics Denmark*, n.d.), however the Transport Sector has announced that there is a growing gap between the number of infrastructure services available to drivers as vehicles on the road are three times as many today (*The International*, n.d.). Per Statistics Denmark, the number of EVs and hybrids on the road increased by 70% in 2022 (to over 112,000 vehicles) compared to 66,600 vehicles in 2021 (*Statistics Denmark*, n.d.; *The Post*, n.d.). And most recently in May of this year (2023) the number of electric cars sold was twice as many as in the same period in 2022 (*Nyhedsoverblik 1. Juni - TV 2*, n.d.).

This is problematic when currently charging services are lacking and fragmented, especially for urban dwellers who rely on on-street charging infrastructure services for their charging needs—which can

slow down EV mass adoption. Chen (2019) found that vehicle owners living in apartments are two and a half times less likely to own an EV in comparison to those with at-home private parking and charging accessibility—termed an EV *'apartment gap effect'*—making a complicated case for Copenhagen to effectively transition from ICE vehicles to EVs when 46% households reside in apartments (*Statistics Denmark*, n.d.; *The International*, n.d.). Large EV penetration requires charging infrastructure, and of its services, that can satisfy all market segments transport needs—thus new ways must be found to push development and to be quick about it (Calearo et al., 2021, p. 5).

2.5 Research question

This thesis makes the following contributions: First, this thesis aims to explore how, and if, service design—at a micro-level of *service as an interaction*—could help to facilitate EV mass adoption in an urban context (Morelli et al., 2021). Second, it aims to identify opportunities to how SD could help to accelerate EV mass adoption (in an urban context)—where previous review barriers and opportunities are taken into account and applied to user-centric research in order to identify possibilities service improvements, and/or innovations, that can address users key pain points in their urban transition to e-mobility.

The main research question addresses: '*How can Service Design, at a micro-level, help to facilitate the transition to electric vehicles (EVs) mass adoption in an urban context?'*

3 Research methodology

This chapter presents the methodologies that were employed to explore and aim to answer the research question. The chapter summarizes with a visual representation of the overall research process.

The chapter is divided into the following subchapters:

3.1 Double Diamond
3.2 Design thinking process
3.3 Research process

3.1 Double Diamond framework

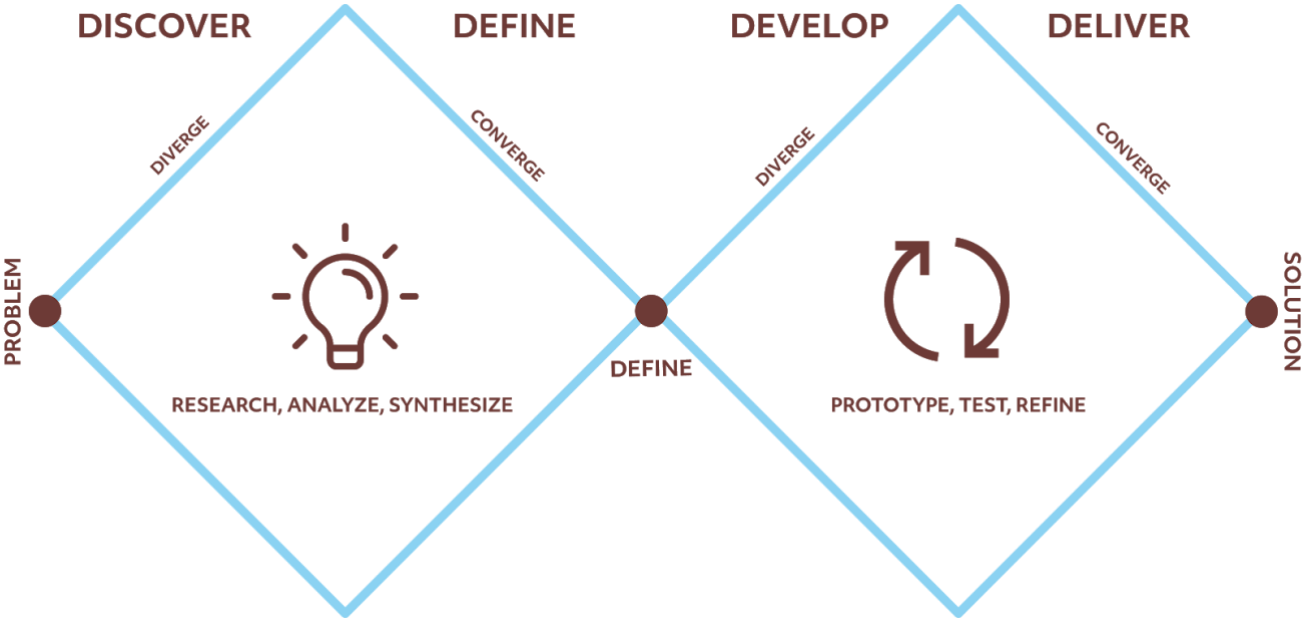


Figure 1—Double Diamond framework—self-adapted (Chavez et. al, 2020; Design Council, n.d.)

The Double Diamond (DD) is a design process model that was developed by the *British Design Council*. It is a visual representation of divergent and convergent stages in the design process (Design Council, n.d.). Because the design process is never a linear process the DD permits service designers to go back and forth in [what is] an iterative and explorative process (Stickdorn & Schneider, 2018). The Double Diamond framework consists of four key phases (*History of the Double Diamond - Design Council*, n.d.; Penin, 2019).

1. 'Discover phase' –The first half of the diamond, explores the problem space and gathers insights. This stage involves conducting research, gathering user requirements, and identifying opportunities and challenges. It is a divergent phase where the focus is on exploring a wide range of possibilities.
2. 'Define phase' –After the discover stage, the second half of the first diamond is the define phase. At this stage insights and knowledge gathered are synthesized to define the problem or challenge more clearly. This process involves analyzing and synthesizing research data, identifying patterns and/or themes and framing a problem statement.
3. 'Develop phase' –Once the problem is clearly defined, the divergent phase commences again in the first half of the second diamond. In this stage, multiple ideas and solutions are generated through brainstorming, prototyping, and by exploring different possibilities. The emphasis is on experimentation and iteration to arrive at the most promising design solutions.
4. 'Deliver phase' –The final half of the second diamond represents the convergent phase of the design process where ideas and concepts developed in the previous stage are refined, tested and implemented. Prototypes are further developed and refined based on user feedback. Here the goal is to create a final, well executed service/product or solution.

Applying the Double Diamond design framework offers several advantages such as having a clear structure, a user-centric focus, divergent and convergent thinking, and in being iterative and flexible. However, there are limitations as well. The DD does not provide detailed guidance on specific design methods or approaches—thus designers may need additional resources to effectively carry out activities at each phase of the framework (UX Collective, n.d.). Overall the DD design framework provides a useful structure for approaching the design process. It encourages user-centric thinking, exploration of ideas and iterative development. However, it is important to adapt and complement the framework with other methodologies and practices to ensure a comprehensive design process (ibid)—hence this thesis utilizes the design thinking process in conjunction to the DD framework.

3.2 Design thinking process

This section will present the design thinking process, and the five stages it is comprised of, pictured below (fig. 2). The design thinking process was found to be a relevant approach to complement the DD framework in seeking to solving user-centric problems and design solutions as it offers detailed guidance on design methods and approaches at each phase of the design process (UX Design, n.d.).

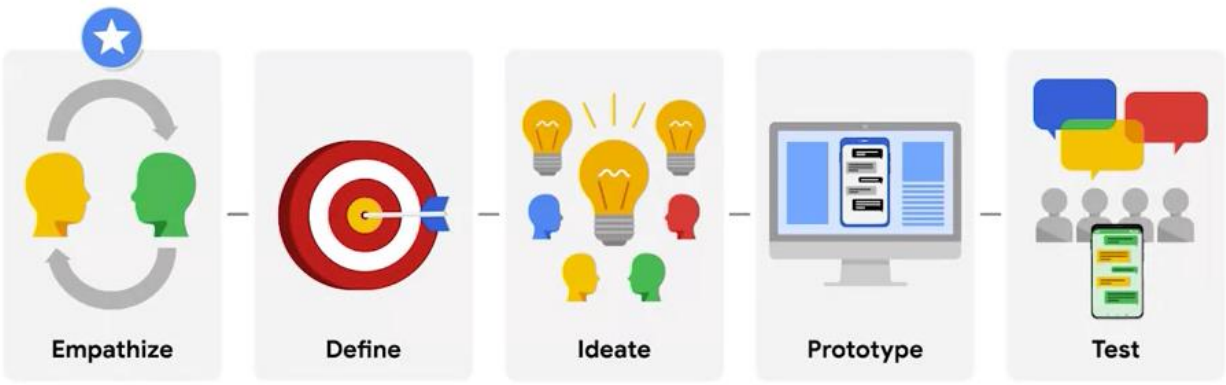


Figure 2 Design thinking process (ibid)

The ‘design thinking’ process, like the Double Diamond, is one type of framework designers can use to organize their approach to designs. This framework helps to: focus on the user; to create solutions that address user needs; to validate design solutions and to iterate the design as needed to create the final desired user service experience (ibid).

The ‘design thinking’ process includes five stages: empathize, define, ideate, prototype and test. Similarly to the Double Diamond (DD), the framework diverges and converges and was applied in conjunction with the DD to complement the design research.

During the empathize phase the primary goal is to learn more about the user—about their problems, wants and needs. User research can include surveys, interviews and observations. In the define phase, user research is analyzed to determine which user problems are the most important ones to solve and

why. After ideating on how to solve the key identified problem, prototyping commences with the goal of an early model of the design solution that can be tested to ensure the right solution is being developed to address the user's problem.

3.3 Research process

Below (fig. 3) visualizes the overall research process of this thesis. It aims to illustrate how the two chosen design methodologies are utilized in the entire design process. The DD serves as a methodology approach to the overall design process – while the 'design thinking process' delineates the complementary stages, or design methods and approaches, undertaken at each phase. A third initial diamond was added to visualize the preliminary inquiry undertaken via a literature review, as aforementioned in chapter 3.

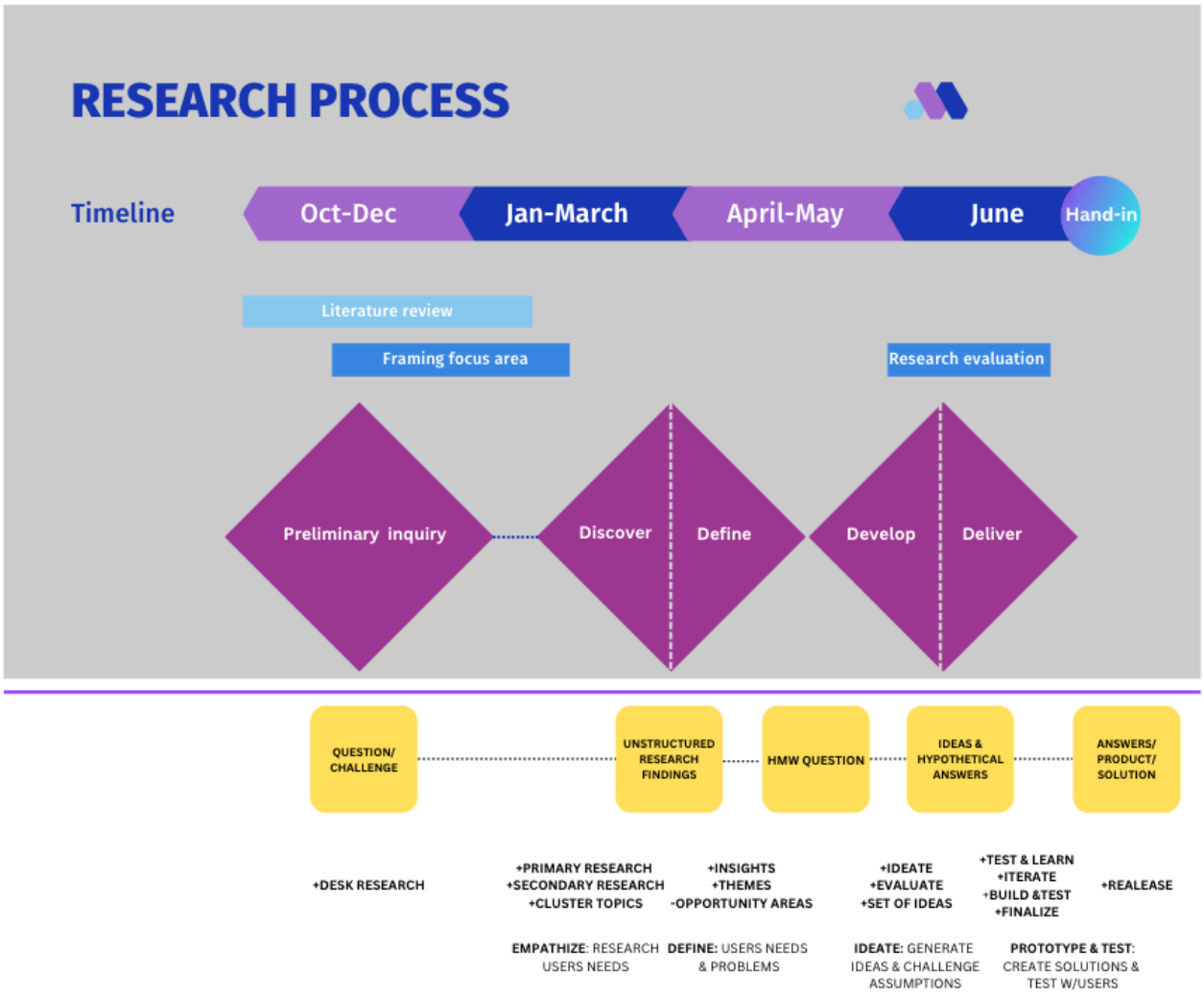


Figure 3—Double Diamond & 'design thinking' process—self-made & adapted from (Design Council, n.d.; UX Design, n.d.; Penin, 2019)

Design process

In this chapter the design process is organized following the Double Diamond's framework.

This chapter is divided into the following subchapters:

4.1 Discover
4.2 Define
4.3 Develop
4.4 Deliver

3.4 Discover

The Discover phase started with the preliminary inquiry literature review, complemented with additional desk research on the market and demographics in Copenhagen to further understand the current context of EVs current adoption—in an urban context—taking into account socio-demographic data, such as of the percentage of urban dwellers residing in apartments. In addition, the discovery phase included mostly qualitative, and some quantitative, data to explore users' environmental circumstances, users behaviors, motivations and frustrations/pain points[1] in their transition to e-mobility.

This subchapter will be divided into the following sections:

4.1.1 Desk research
4.1.2 Messy brainstorm map
4.1.3 Field research
4.1.4 Mixed method online survey
4.1.5 Seeking interview participant flyers
4.1.6 Semi-structured UX interviews
4.1.7 Empathy maps
4.1.8 Conclusion to the Discover phase

3.4.1 Desk research

A key preparatory step in the 'discover' phase of the design process is to gain a preliminary understanding of the current context/situation of the design challenge. For this initial part of the process, secondary desk research was useful to gather and synthesize already existing research/data, achieved through the literature review and additional market research about Copenhagen (Stickdorn

[1] Pain points are any issue that frustrates or blocks the user from getting what they need (*User Research in UX Design: The Complete Beginner's Guide*, n.d.).

& Schneider, 2012). The results of this desk research were presented in the project context in chapter 2.

The conducted desk research—in addition to the preliminary inquiry—allowed for further exploration of the context of EVs mass adoption in an urban context in Copenhagen. Focus was especially placed on investigating EVs current market development, user demographics and on current EV services offerings—such as with charging infrastructure services for urban dwellers residing in apartments who are outside of niche market segments of those users with at-home parking and charging accessibility.

3.4.2 Messy brainstorm map

The messy brainstorm map was a visual tool applied at the start of the discovery phase to help generate and organize ideas by exploring various concepts and connections (StudySmarter, n.d.). This method was applied to help piece together the preliminary findings from the literature review and to help guide possible research directions, for further investigation, in relation to EV users and of potential needs and challenges they may be facing. Possible pain points were marked with a 'P', while possible opportunities for improvements were marked with a star. Illustrated in below fig. 4.

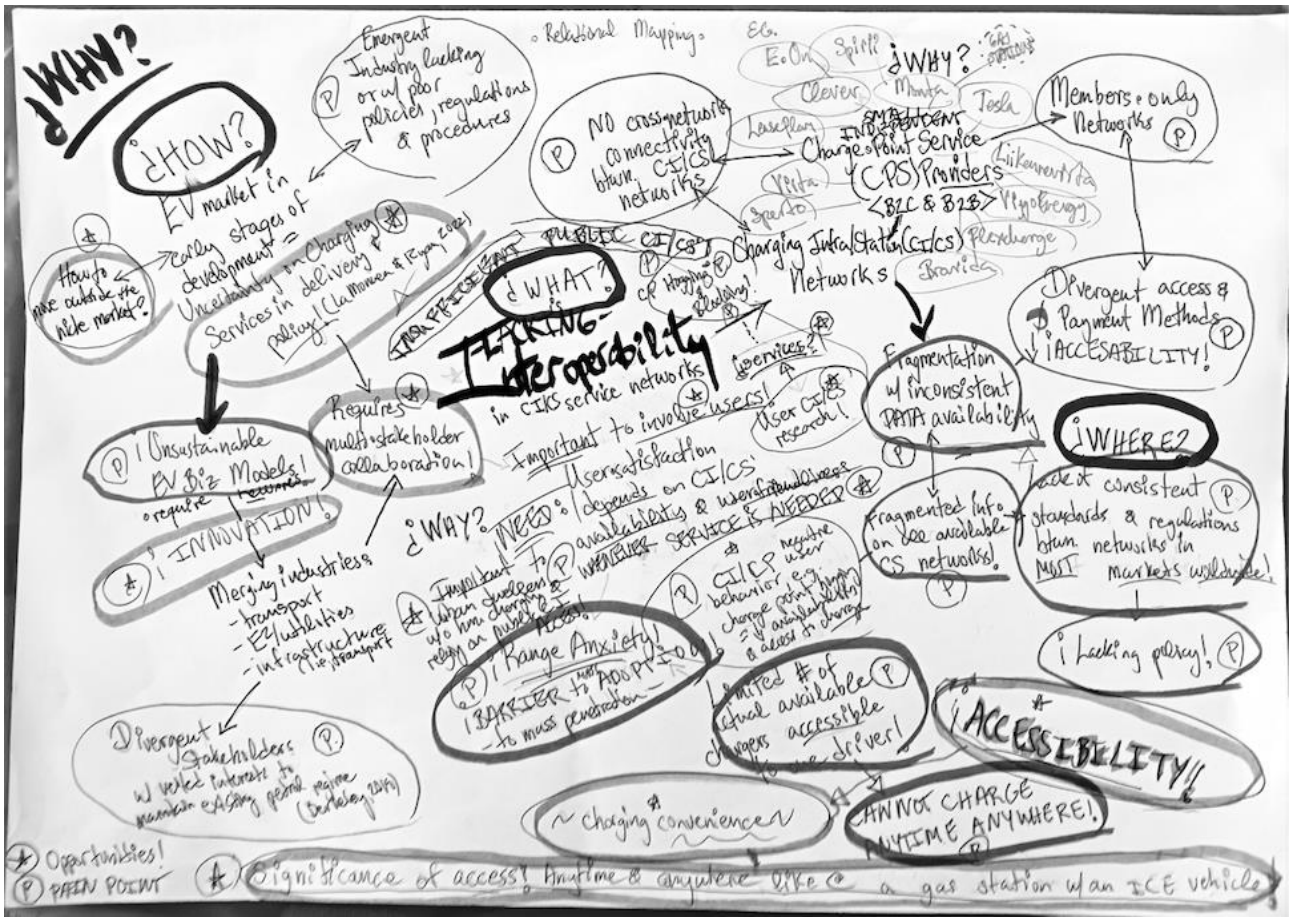


Figure 4—Messy brainstorm mapping – self-made

Summary

Following the desk research and messy brainstorm map, the information and ideas derived inspired undertaking ethnographic field research to explore in real-time, and in context, what is happening with users at charging stations in Copenhagen.

3.4.3 Ethnographic field research

Ethnographic field research involves service design researchers to immerse themselves and to explore services in real context situations, such as that of being an EV user (Stickdorn & Schneider, 2018). This type of research can facilitate interpretation of user behaviors and/or situations users may encounter within the given service context (ibid).

The field research was conducted between April 1st and May 1st. During this time period various charging station service points—and their service providers—were explored in various neighborhoods in Copenhagen which included: Amager, Frederiksberg, Christianshavn, Vesterbro, Indre by and Nørrebro. Here everything was observed from users utilizing charger points to the set-up of the charging station—such as with the number of chargers/parking spaces available, the amount of vehicles charging, the signage indicating charge points and time limits, or lack thereof. And in observing possible pain points for EV users such as non-charging vehicles blocking chargers for EV users.

Furthermore, the field research included approaching EV users to seek out ‘quick and dirty’ conversations about their current experiences as EV users. During these conversations the aim was to engage in a casual conversation seeking to explore users’ motivations, needs, pain points—to explore experiences and emotions—and follow up with questions such as ‘how did this situation make you feel?’(Ethnographic Field guide, n.d.).

Figure 5—Field research photos—self-made

Key insights and preliminary reflections

⇒ There was a vast difference between neighborhood's in regards to the amount of charging stations and in availability of charge points. For example, Frederiksberg had the most charging stations with charging stations found within two to three blocks from each other.

⇒ Charging stations with designated time parking limits were not as occupied, or completely full with vehicles, as charging stations without time parking limits.

⇒ A common theme, and what seemed a possible key pain point, emerged at all neighborhoods visited (with the exception of Frederiksberg). Vehicles parked at charge points but not charging, hence blocking chargers for those who may need them—and in observation this was not only ICE vehicles but also EVs (illustrated above in fig. 5 and below in fig. 6).

⇒ During a couple 'quick and dirty' conversations it was found that one EV user, living in an apartment, had only recently switched to a full EV because he now had chargers at work but stated that without that accessibility he would not have made the transition. He felt that the charging infrastructure in Copenhagen is insufficient so he would not have purchased his EV if he did not have at work charging access. Another EV owner was struggling with the charger he had plugged into as he realized the car had not charged. He stated that he had left his car charging there the previous day—he was parked at a charging station without time limits allowing him to leave his car parked overnight. He expressed he had just a few months ago purchased this hybrid EV, and liked it because he can drive fully electric in the city when he has the accessibility to charge his vehicle. But currently

he was frustrated and was waiting on his phone for charge point service (CPS) provider's customer service to find out why his car had not charged.

⇒ It soon became apparent that finding more users to speak to was a difficult task as it was not very common to run into users at charging stations. And the few times when users were encountered they would be in a hurry to their next destination. This led to ideating on what could be the next step, or steps, to gain more user insights. This led to the creation of a user experience (UX) mixed method online survey—as well as to creating laminated flyers to place on vehicles at different charging stations, in different neighborhoods to seek out willing interview participants (appendix 1).

Figure 6 – Field research photos—self-made

3.4.4 Online mixed method online survey

Following the insights gained during the ethnographic field research, an online mixed method Google survey was created. Surveys tend to be used for descriptive or exploratory research such as with seeking out attitudes or opinions (Saunders, 2016). The aim of this survey was to quantitatively seek out: what types of homes respondents lived at (i.e., those living in multi-unit dwelling versus private homes); if respondents found on-street public charging infrastructure to be sufficient and to see how respondents rated charging services[2]. Qualitatively, the survey (through open questions) sought to gain more insights from users in regards to their experiences with being EV owners, or leasers—and

[2] Based on the number of respondents, the quantitative data was not taken into account in the end as it was not a large enough sampling. But the number of respondents was deemed sufficient to validate the qualitative data collected.

this included inquiring if users had experienced the aforementioned observation, during the field research, of finding charge points blocked by non-charging vehicles.

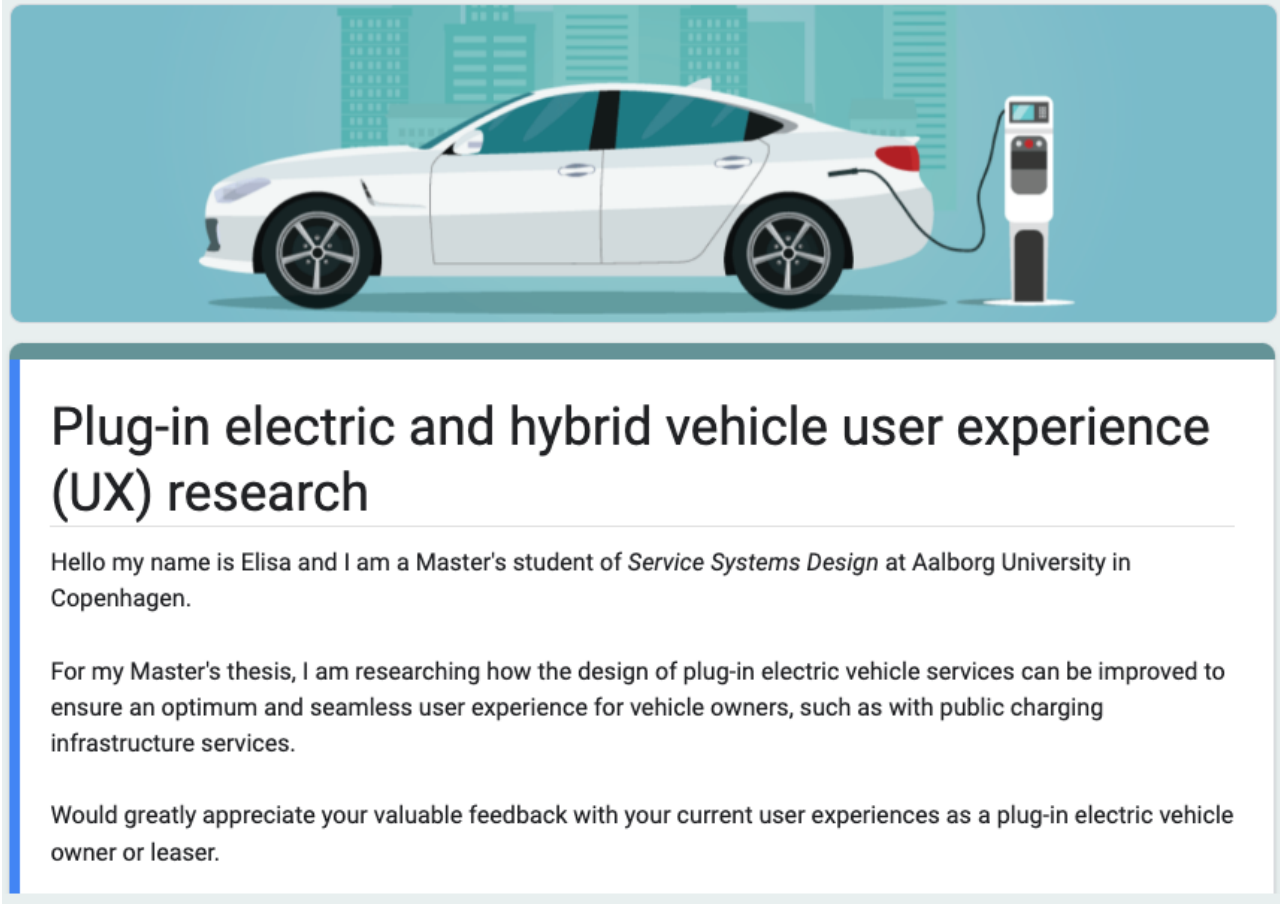


Figure 7—Self-made via Google Forms (Appendix 2)

Prior to sharing the survey a pilot test was performed to ensure respondents could actually complete the survey and to refine questions if necessary (Saunders, 2016). The online survey was open for respondents between March 20th and May 20th. It was shared through social media channels that included LinkedIn, Facebook, Instagram and via email. In order to generate a broad range of participants, the survey was shared amongst friends, family, colleagues and via the participants networks. The result was a total of 38 respondents. Though this number could be deemed as a limitation, as it is not a large sampling, due to the nature of the research in terms of qualitative data the research goal was to get between 30 to 40 respondents. This amount was considered to be sufficient to gain further qualitative insights into users' needs and experiences as EV drivers.

Key insights

⇒ *Vehicles owners that chose to drive a plug-in hybrid EV (PHEV) over a full EV expressed the following reasons for their choice:*

Figure 8—User comments—self-made via Google Slides

The purpose with this initial question was to investigate if driver's were choosing hybrids over full EVs due to lack of available charging infrastructure—as transitioning to a hybrid first, ensures that those relying on on-street charging services will not run out of power when they are unable to find a place to charge their vehicle. The above responses confirmed this hunch to be the case.

⇒ *When asked if respondents experienced finding a charger blocked by a non-charging vehicle, the following responses were provided:*

Figure 9— User comments—self-made via Google Slides

These responses confirmed that this is a major pain point that EV users frequently encounter in finding vehicles blocking accessibility to chargers. Additionally, another key problem mentioned by

one user is that of plugged-in EVs that take up chargers even after being fully charged—which is problematic as the "*number of EVs has skyrocketed*" while sufficient CI services are still lacking.

⇒ *In additional comments respondents shared the following:*

Figure 10— User comments—self-made via Google Slides

Preliminary reflections

Combined with the ethnographic field research, insights from the survey provided invaluable feedback on users current experiences. These findings thus contributed to ideas for further investigation of users current experiences and pain points (in their transition to EVs) by seeking out participants for semi-structured interviews—as interviewing users is essential to understanding their perspectives and to learn about their pain points (Coursera, n.d.).

3.4.5 Seeking interview participants

The participants selected for the interview research were based on the below research goals and target users characteristics.

Research goals

⇒ To understand the processes and emotions that people experience around the problem my service/product wants to try to solve—such as a way to ensure charging service accessibility when it's needed.

⇒ To identify the frustrations people experience (pre, during or post) the charging process, or when wanting to charge their vehicles, or with service providers, or with service apps, or with other users behaviors, or with making complaints, or with the municipality, etc.

⇒ To understand common EV user behaviors and experiences with the task that my product/service will attempt to address—such as with the lack of charging infrastructure, lack of charging accessibility when needed, with other drivers unwanted behaviors, with lack of policy/governance of EV services, etc.

⇒ To evoke user stories and to explore their emotions (Ethnographic Field guide, n.d.).

Characteristics of target audience

- Ages 18-75
- Include all genders, or non-genders
- Delimitation: Urban dwellers that rely on street charging stations for their charging needs
- Users that DO NOT have access or availability to private at-home charging

HAS THIS HAPPENED TO YOU BEFORE?

Description: internal combustion vehicle blocking a charging point

Plug-in electric and hybrid vehicle user experience (UX) research

Currently, I am seeking participants who want to partake in a brief interview (online or in person) to share current experiences as plug-in electric or hybrid vehicle owners (or leasers).

**In compensation for your valuable input and time, you will be awarded a DKK 150- gift card to a place of your choosing.*

PROJECT DETAILS

- Seeking participants who **do not** have private at-home charging accessibility (ergo, you rely on street charging stations and/or at work)
- You are 18 years old and over
- Interviews can scheduled between April 2nd and May 2nd (*holiday dates excluded) and if not online, we can arrange what is the most convenient location for you

CONTACT INFORMATION

If you wish to participate, or have any questions, you can contact me directly at:

Elisa Chavez

gchave20@student.aau.dk

Figure 11—Self-made flyer to seek out interviewees, placed on charging vehicles windshields at various stations and neighborhood's in Copenhagen

Flyer distribution details

⇒ The above (fig. 11) laminated flyers were placed on over 30 charging EVs windshields at various charging stations located in: Amager, Christianshavn, Vesterbro, Indre by and Nørrebro.

⇒ The flyers were distributed between March 26th and April 13th

⇒ The end result was four interview participants who were interested to participate in the research.

Following the completion of the fours interviews, before entering the define phase of the DD, empathy maps were created in order to record the learned and observed user needs, behaviors and motivations that were revealed during the interviews—examined further below in section 4.1.6.

3.4.6 Empathy maps

Zooming into *service as an interaction* (Morelli et al., 2021), the user's experience is at the center of how to design services/products. To create great user experiences it is imperative to empathize with the user (*Build an Empathy Map | Coursera*, n.d.-b). Here, empathy maps are a great tool used in the design thinking process that help explain what has been learned about users' needs, motivations and behaviors—they can help break down each interview into digestible pieces of information and thus help to empathize with users (ibid). There are two types of empathy maps: *one-user empathy maps* and *aggregated empathy maps*. *One-user empathy maps* are based on data from one user's interview to help distill a user's thoughts, feelings and behaviors (*Empathy Mapping: The First Step in Design Thinking*, n.d.). Aggregated empathy maps are created based on multiple one-user empathy maps that are combined based similar things, helping to identify segments (or people) with similar tendencies (ibid). Overall, empathy maps are valuable tools for understanding users and to foster empathy, however they are not a replacement to other design research methods such as user journey mapping, scenarios or user flows—which all play an important role in the design process in order to ensure a comprehensive understanding of the user's needs and experiences (*What Is an Empathy Map? [Complete Guide]*, n.d.).

One-user empathy maps

Here is a link to better view the empathy maps should it be difficult to view them in detail here:
https://docs.google.com/presentation/d/1wql8Ug9vuK6-f0wjEGK3DvajhFHKZTyv/edit#slide=id.p6

Federico

Says -Chose a hybrid over an EV because not sure of driving range for long distance -Not sure how many CPS providers apps exist -There is not enough charging infrastructure (CI) in Copenhagen, especially where he lives	**Thinks** -Thinks the municipality does not care to do anything about blocked chargers or of creating more infrastructure -Thinks that not having time limits for chargers makes it more difficult to find available chargers as people do not have to unplug their vehicles & move their cars -Thinks a good solution is for the municipality to give fines to those blocking chargers & to provide parking time limits so people do not "hog" charge points
Does -Charges hybrid on-street where chargers are available -Tried to contact service provider about blocked chargers by other cars & told they cannot do anything, that he needs to contact the municipality -Has not contacted the municipality because does not want to waste his time as he does not think there is much understanding for this situation & that it is all very bureaucratic	**Feels** -Very frustrated when the CPS provider app shows an available charger but when he arrives it is being blocked by an unplugged car, or it is out of service -Annoyed that nothing is being done by the municipality as CPS providers have told him they cannot do anything, that it is up to the government to regulate

Figure 12—Federico Empathy Map—self-made via Google Slides

Michael

Says	Thinks
-He drives a hybrid because he travels frequently and a full EV is no compatible when there is lacking infrastructure -He relies on on-street charging as does not have at-home accessibility -Says there is an issue that there are no associations and apartment buildings where owner associations must establish shared charging facilities	-Thinks the local and national government can play a key role on the expansion of infrastructure, such as with regulations on how many parking spots must be provided in new buildings, shopping malls, etc. -Monta app is too expensive as it works like a payment app allowing access to all service providers but with variable & expensive prices -Thinks one of the main obstacles to transition to EVs is the inability to refuel EVs like petrol vehicles can at gas stations -Thinks an incentive for the 3-4 biggest supermarkets in DK to roll out local access to charging infrastructure could work great as they already have the space, with unmanned gas stations, etc.– "so why not do it there?"
Does	**Feels**
-Does have problems finding on-street chargers as sometimes none are available near his home -Has never contacted the service provider or municipality because it's too much work	-"The most annoying things is when spaces are occupied by cars that are not charging. It sucks when that happens and sometimes it is even EVs that are not charging!" -Annoying to have an account with a service provider that shows an available charging spot but on arrival the spot is occupied by a non-charging car

Figure 13—Michael Empathy Map—self-made via Google Slides

Peter

Says	Thinks
-Says there is not enough on-street infrastructure -"Everybody nowadays has a hybrid or EV so you're lucky if you can find a charger, especially when I come home from work– it is impossible to find a charger & there is no time limit so cars can just stay plugged in." -He has never tried to contact the service provider about vehicles blocking a charger -Says he loves his hybrid but wishes they made them with a longer driving range. Currently his hybrid can only drive 50km on electricity	-Charging infrastructure is behind on development -That maybe after 2025, when petrol cars are banned and people start changing to EVs, that charging infrastructure will come
Does	**Feels**
-When a car is blocking a charger he just tries to find another available charging spot near his apartment -"I am lazy and don't want to walk too much"	-"It's annoying when cars block chargers, but it is not illegal"

Figure 14—Peter Empathy Map—self-made via Google Slides

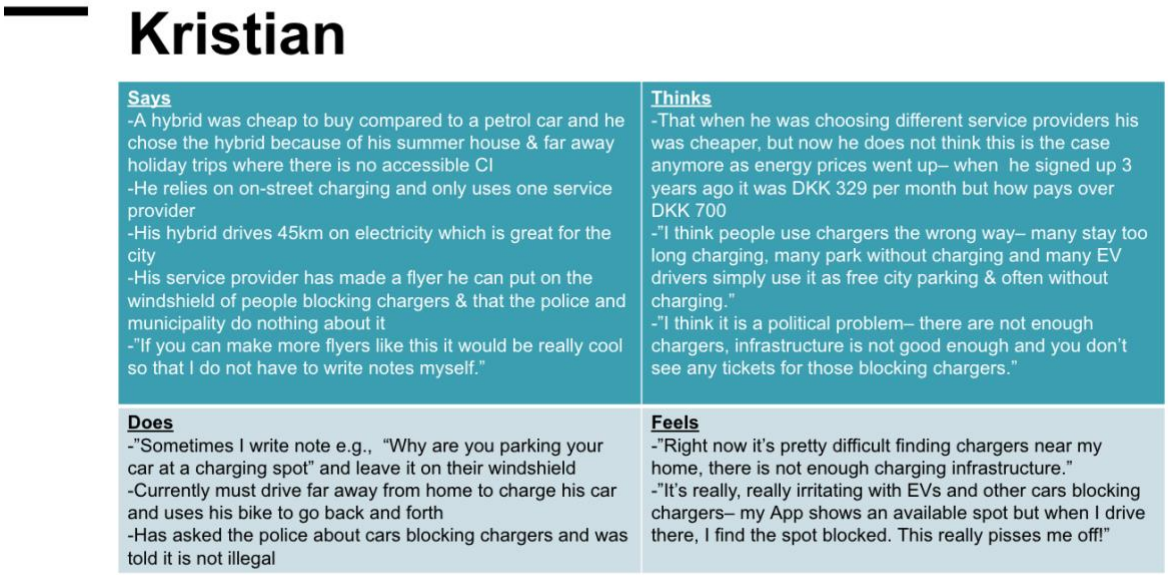


Figure 15—Kristian Empathy Map—self-made via Google Slides

Aggregated empathy map

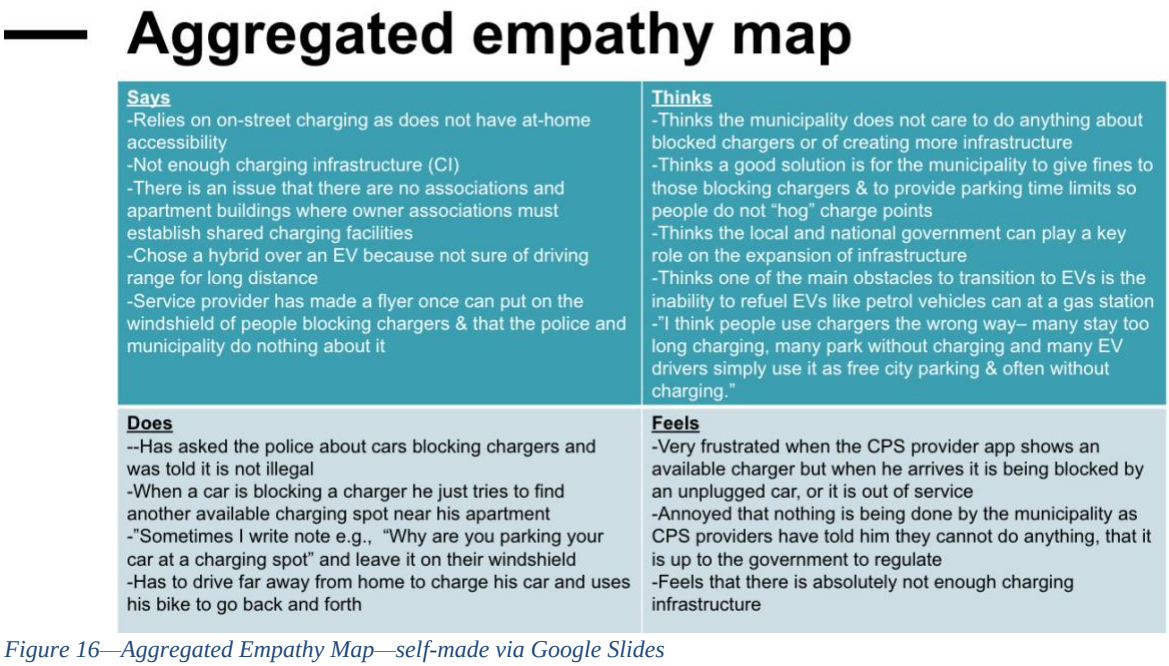


Figure 16—Aggregated Empathy Map—self-made via Google Slides

Preliminary reflections

The primary user group identified are adults that reside in urban city areas and who rely on on-street charging infrastructure for their charging needs. This group confirmed initial assumptions—as well as validated survey findings—about the lack of sufficient available charging infrastructure, the lack of accessibility to charge their vehicles where and when they need it, and of the frequently experiencing the common pain point of driving up to charge points to find them blocked by non-charging vehicles (even though their service app shows them otherwise). Lastly, another key finding was users having frustration with Copenhagen municipality in not doing anything about vehicles that block chargers as currently it is not illegal and/or fineable—and CPS providers are therefore unable to do anything about it unless the CS' are in private parking lots (Appendix 3).

3.4.7 Conclusion of discover phase

⇒ In the discover phase, various service design research methods were applied in order to understand urban EV users current experiences in their transition to e-mobility. The conducted desk research, in addition to the preliminary inquiry, allowed for further exploration of the context of EVs mass adoption in an urban context in Copenhagen. And on current EV services offerings—such as with charging infrastructure services for urban dwellers residing in apartments who solely rely on on-street charging services (and of their accessibility) for their charging needs.

⇒ During the ethnographic field research, 'quick and dirty' conversations with EV users enabled casual and brief conversations that provided a better understanding of users motivations, needs and pain points—and this approach quickly revealed that finding users to speak to on-the-go was not best research strategy as encounters with users were infrequent, and when drivers were encountered they were typically in a hurry to their next destination.

⇒ Combined with the ethnographic field research, qualitative insights from the survey provided invaluable feedback on users current experiences as EV drivers thereby facilitating clear research goals and a target audience attributes in seeking out participants (and in conducting) the semi-structured interviews.

⇒ Finally, the knowledge gathered during the interviews and applied to empathy maps helped to build an empathic understanding for urban EV users current experiences in their current transition to e-mobility.

3.5 Define

In the define phase all research findings were analyzed and synthesized. The various insights gained enabled defining clear problem statements to enter the design process ideation phase that would lead into the develop phase of the design process.

This subchapter is divided into the following sections:

4.2.1 Personas & user stories
4.2.2 User journey maps
4.2.3 Problem statements
4.2.4 Conclusion of the 'define phase'

3.5.1 Personas & user stories

Based on all the research findings that were analyzed and synthesized—and with help of the empathy maps—the users' needs, motivations, behaviors, and pain paints enabled to commence the building of personas. Personas are fictional archetypes that aim to represent a group of users with similar characteristics—learned via the user research—and are key in the design process to reflect upon the users lifestyles and thus to provide ideas on how to meet users' needs and/or challenges (*Learn More about Personas | Coursera*, n.d.).

Four personas were created, which is considered sufficient when representing the majority of a service/product user base (ibid)—in this case being urban dwellers who depend on on-street charging services for their charging needs. These personas were based on the most common themes in the data, such as was illustrated in the aggregated empathy map (sub-section 4.1.6). It is important to note these personas are context-specific, focused on user behaviors and with well-defined goals to meet their specific needs based on the data collected from users (*Learn More about Personas | Coursera*, n.d.; *Why Personas Fail*, n.d.).

The below created personas (fig. 17-20) were focused on common themes from the analyzed and synthesized data derived from the field research 'quick & dirty' conversations, the mixed method survey and the semi-structured user interviews. The personas created have clearly defined goals and frustrations in relation to their needs as urban dwellers who rely on on-street charging services. These personas are further defined by the utilization of a user story for each persona. A user story is a fictional one-sentence story from the persona's point of view, communicating everything you need to know about the persona(*Learn More about User Stories | Coursera*, n.d.; *User Stories: As a [UX Designer] I Want to [Embrace Agile] so That [I Can Make My Projects User-Centered] | IxDF*, n.d.). A user story should be short, specific and goal oriented—helping to develop early solutions by defining which needs to focus on (ibid). User stories can help to ensure that designers are addressing and trying to solve the key pain points, or challenges, users may encounter when engaging with the

product/service (*User Stories: As a [UX Designer] I Want to [Embrace Agile] so That [I Can Make My Projects User-Centered] | IxDF*, n.d.)

Here is a link to better view the personas if it is difficult to view them in detail here: https://docs.google.com/presentation/d/153ztn6kdRFGuoSLevjCf1-S2LKFNDVc5r7pYXmy4new/edit?usp=sharing

Persona no. 1—Niels

Figure 17— Niels persona—self-made via Google Slides

User story

"As a caring and concerned father and grandfather, I want to be confident that the national and local government will roll out more charging infrastructure so that everyone can transition to green mobility to help meet emissions target reductions by 2030."

Persona no. 2—Federico

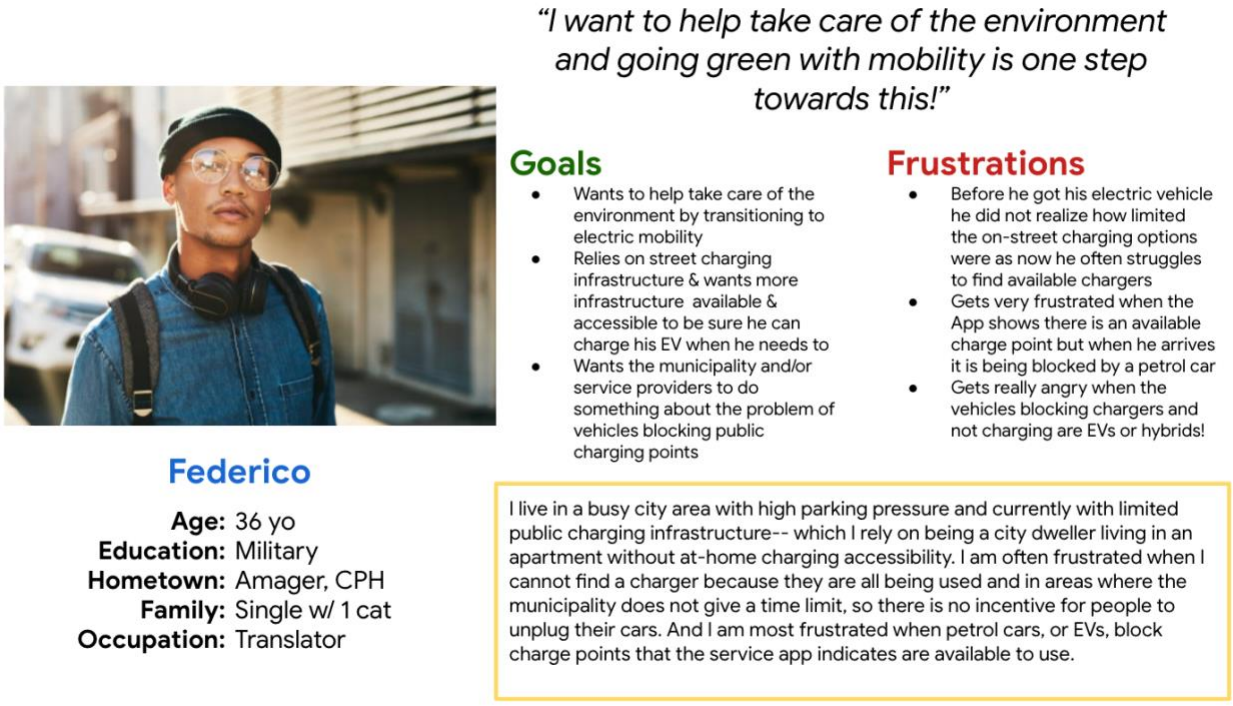


Figure 18— Federico persona—self-made via Google Slides

User story

"As an EV driver who relies on on-street charging stations, I want to be certain that there is a charging space available, as indicated on the service app, so that when I arrive I have not wasted my time driving to an unavailable charger."

Persona no. 3—Marie

Figure 19— Marie persona—self-made via Google Slides

User story

"As a dedicated environmentalist, I want to be able to drive a 100% electric vehicle without worrying about when and where I can charge it so that I will not be left stranded without electricity to power my car."

Persona no. 4—Kristian

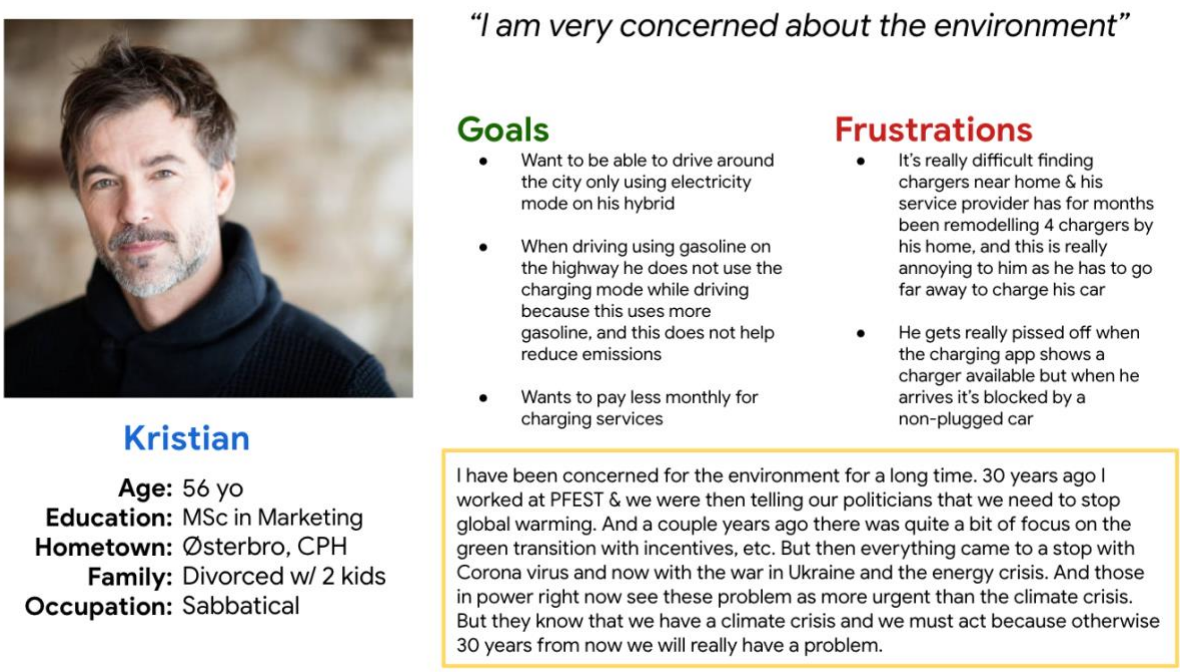


Figure 20— Kristian persona—self-made via Google Slides

User story

"As a busy single parent, I want to be able to easily and conveniently charge my car near my home so that I do not have to park far away from my home ,with my children, in order to charge my EV."

Summary

	Goals	*Frustrations*
Niels	Wants to be able request charge points for the municipality to install as is done in the Hague (*The Hague - Request Charging Point for Electric Car*, n.d.)	Complicated & expensive to get CI installed at his apartment building & out of his pocket
Federico	Wants the municipality and/or CPS providers to do something about the problem of non-charging vehicles blocking chargers	Very frustrated when the service app shows him an available charger to arrive & find it blocked by a non-charging car
Marie	Wants to be able to charge when & where she needs to just as ICE vehicles are able to at any gas station	Anxious getting home after work as chargers are often taken up quickly & with cars left all night charging—leaving her unable to charge
Kristian	Wants to be able to easily & conveniently charge his vehicle near his home	Really difficult finding chargers by his home & finds it really annoying as he has to go far away to park & charge his car

Table 2—Summary of goals & frustrations—self-made

In having created the above personas and user stories, the above (table 2) summarizes clearly defined goals and frustrations established in relation to each personas' needs as urban dwellers who rely on on-street charging services. These clearly defined persona goals and frustrations help to bring an empathetic and user-centric focus in the design process—enabling service designers to focus on creating product/services experiences that align with users' needs.

3.5.2 User journey maps

The summarized personas goals and frustrations formed the basis of creating user journey maps to help illustrate the possible steps, interactions and emotions of the users as they engage with the product/service or experience (*Journey Mapping 101*, n.d.). User journey maps are a common user-centric tool which can come in various different shapes, sizes and formats—with the purpose of visualizing the process/narrative a user goes through in order to achieve a goal, such as with charging their EV (ibid). User journey maps, provide a holistic view of the user's end-to-end journey, from initial contact to the desired outcome (ibid). Creating personas and users journey maps are two complementary tools to help understand the needs and experiences of users.

The below user journey maps for each created persona (fig. 22-27) are in the following format: At the top, the 'action' row examines the end-to-end user journey being taken in order to achieve the user's desired end goal. In the 'task list' row, possible tasks that must be accomplished at each stage of the process are input. Within the 'feeling adjective' row, possible feelings that could be experienced are written and marked with an emoji. In the last row, 'improvement opportunities' are taken into consideration.

Here is a link to better view the user journey maps, as below they may difficult to view here in clear detail.
https://docs.google.com/presentation/d/1l1y61ZXlrOByDKYkOxSZRLnCIdOFXyMP/edit?usp=sharing&ouid=105294063968981884239&rtpof=true&sd=true

Persona no. 1—Marie

Figure 21— Image (Shutterstock, n.d.)

Marie has the goal to find an available parking spot to charge her EV near her home after getting off work when parking pressure is high.

Persona: Marie

Goal: Find an available parking spot for charging her vehicle when getting home after work

ACTION	Drive home from work	Look for nearest charging station near her home	Find an available charger to park & charge	Plug in her hybrid to the charger	Use her RFID card to commence charging	Ensure car is charging & head home
TASK LIST	Tasks A. Get in her car after work B. Drive to her neighborhood	Tasks A. Arrives to her neighborhood B. Drives around checking for available chargers near her apartment	Tasks A. Find an accessible charger B. Park her hybrid	Tasks A. Take out charge cord B. Plug in charge cord to her car C. Plug in charge cord to the charge point	Tasks A. Uses her charger service card to initiate the charging process B. Takes her items out of the car and locks it	Tasks A. Double checks charge point screen & car light to ensure the charging process is underway B. Walks two blocks to her apartment
FEELING ADJECTIVE	- **Happy** the workday is over 😁 - **Hopeful** traffic will not be too bad🙏	- **Anxious** she won't find a charge point😖	- **Happy** she found a charge point parking spot near her apartment😊	- **Happy** it's Friday and she found a charger😊	- **Happy** to be parked to plug-in for charging 😊	- **Worried**🙂 the charger could be malfunctioning, but **thankful** everything appears okay😌
IMPROVEMENT OPPORTUNITIES		1. Reservation service app to book an available nearby charger	1. Reservation service app booking ensuring she has a charger waiting for her upon arrival & near her home		1. Charing service commences automatically once she plugs in her hybrid to her reserved charger	1. App indicates beforehand if a charger is not accessible OR 2. App indicates only functional chargers to reserve

Figure 22—Marie User Journey—self-made via Google Slides

Persona no. 2—Federico

Federico has the goal to find an available, non-blocked, charger via a CPS provider's app.

Figure 23— Image (Shutterstock, n.d.)

Persona: Federico

Goal: To find an available charger via the charge point service providers app

ACTION	Look up the App's GPS to find free charge points	Drive to the closest charger listed as available	Find the listed available charger is blocked by a non-plugged car	Look up another CPS providers App for available charge points	Drive farther to other available charge point	Park car and plug into the charge point & activate via App
TASK LIST	Tasks A. Opens charge point service provider app B. Looks up his apartment location to see available charge points	Tasks A. Get into car B. Drive to closest listed available charger to his apartment	Tasks A. Arrives at location to find charge point unavailable B. Takes out phone to look up another available charger	Tasks A. Opens another CPS provider app B. Finds an available charge point four blocks away	Tasks A. Drive to new charge point location B. Arrives at new available charge point location	Tasks A. Parks his car B. Gets out of car and plugs in charger cable to the car and the charge point C. Activates charging process via the CPS provider's app
FEELING ADJECTIVE	- **Anxious** if the listed charger will be available and not blocked by non-charging cars or out of service 😠	- **Hopeful** the charger will be available as is still listed to be on the App🙏	- **Angry** the charge point is blocked by a vehicle that is no using the charger😡 - **Annoyed** to have to find a new available charger😒	- **Frustrated** to have to use another CPS provider app😠	- **Annoyed** the new charge point is much further away from home😒 - **Relieved** that the charge point is actually available😌	- **Happy** the car is parked, plugged in and via the app he can see: the charging process is underway; how long it will take and how much he will be charged for plug-in time 😀
IMPROVEMENT OPPORTUNITIES	1. A way for the app to show that a charge point is blocked and/or out of service	1. App showing a percentage probability of the space being available based on peak-time and off-peak time data	1. A way for the app to show that a charge point is blocked so this situation does not happen	1. An app to see and access all CPS providers		1. An app that provides access to all CPS providers & enables charging payment w/ debit cards w/o having to have a membership to all CPS providers

Figure 24—Federico User Journey—self-made via Google Slides

Personas no. 3 & 4—Niels & Kristian[3]

Niels and Kristian have the goal to apply for the installation of a charging station or charge point at their apartment buildings'—or nearby—curated by Copenhagen Municipality.

Figure 25 Figure 26— Images (Shutterstock, n.d.)

Personas: Niels & Kristian

Goal: To apply for a parking space charge point at his apartment building, or near it, curated by Copenhagen Municipality

ACTION	Enters the website	Finds 'parking, traffic & roads' weblink	Finds weblink for 'parking'	Finds 'electric car & charging stations' link	Chooses weblink for 'suggestions for where charge points are missing'	Applies for a 'requesting a charge point'
TASK LIST	Tasks A. Opens laptop and look up the website B. Navigates through the listed options	Tasks A. Clicks on the 'parking, traffic & roads' weblink B. Reads all available link options	Tasks A. Tabs on web link for 'parking' B. Reads through the various text options	Tasks A. Tabs on 'electric car & charging stations' link B. Reads through the entire page C. Tries to decide which link to select	Tasks A. Clicks on web link B. Drop down menu opens for another link to designate locations on a map, and clicks this	Tasks A. Clicks on 'suggestions' link B. Waits for new page to upload
FEELING ADJECTIVE	- **Annoyed** site is only in Danish but glad he can use Google Translate feature 😒 - **Confused** by all the different choices & not sure what to click😒	- **Unsure** he has clicked the correct link as nothing in the text indicated e-mobility 😒 - **Unsure** on what to choose as all links do not show what he is looking for 😒	- **Annoyed** as not sure he is in the right link and there is too much text 😒 - **Glad** he finally found the 'electric car & charging stations' link 😊	- **Glad** he is finally on the e-mobility weblink 😊 - **Annoyed** he cannot find a link for requesting a charge point & only for future suggestions 😒	- **Annoyed** that there is not a clear form to request charge points, only for suggestions for the possible future 😒 - **Annoyed** he must click on another link again 😒	- **Annoyed** the new webpage link is taking a very long time to upload & annoyed it's only in Danish & Google Translate feature does not work here 😒
IMPROVEMENT OPPORTUNITIES	1. Offer text in English 2. Make link choices easier to understand, with less text & clear descriptions to navigate to 'electric mobility' link	1. Same as before	1. Decrease the amount of text on screen 2. Clear description & link for "electric car & charging stations'	1. Make a link for requesting a charge point, on-street or within an apartment building's parking lot	1. A clear 'request a charge point' link that you only click on once	1. Offer text in English option 2. Rather than choosing points on a map make a request form to fill out and submit request

Figure 27—Niels & Kristian User Journey—self-made via Google Slides

[3] Niels' and Kristian's personas were combined as they both have similar goals they want to achieve.

Summary

The user journey maps helped to provide a narrative to how users' may experience their end-to-end user experience with the product/service as they attempt to achieve their goals—providing a holistic view at each point of contact (or touchpoint) and helping to identify possible pain points and to ideate on possible opportunities for improvement. The next step is in defining problem statements. Problem statements have a connection with users' pain points and minimizing these pain points ensures user-friendly experiences that keep users interacting with the product/service (*Define Problem Statements | Coursera*, n.d.).

3.5.3 Problem statements (ibid)

Personas and user journey maps are valuable tools in understanding and mapping out problem statements. The aim of mapping out problem statements is to give a clear description of the user need that should be addressed thereby helping to provide clarity about users' goals. Problem statements can be built with the *'5 Ws and H'* framework.:

- '*Who is experiencing the problem?'*
- *'What are the pain points to solve?'*
- *'When does the problem occur?'*
- *'Where is the user when using the product/service?'*
- *'Why is the problem important?'*
- *'How are users reaching their goals by using this product/service?'*

Below (fig. 28-31) applied the*'5 Ws and H'* framework to map out a clearly defined problem statement to be solved for each of the four created personas.

Persona no. 1—Niels

Figure 28— Image (Shutterstock, n.d.)

WHO—Niels is a caring father & grandfather
WHAT—Pain point of lacking on-street charging infrastructure
WHEN—Experiences problem of lacking CI on a daily basis
WHERE—In Copenhagen in general, and in his neighborhood near his apartment
WHY—This problem is important because more CI is needed to meet the charging needs of all EV users
HOW—Wants to be able to reach this goal by somehow being able to influence/request more infrastructure development

Niels is a caring Father & Grandfather who needs a way to influence the national and/or regional government to build more CI because there is not enough of it to meet the charging needs of all in order to be able mass transition to e-mobility by 2030.

Persona no. 2—Federico

Figure 29— Image (Shutterstock, n.d.)

WHO—A citizen living in a busy city area
WHAT—Pain point of the charging app showing available charge points when they are NOT
WHEN—Problem occurs frequently when he is looking for a place to park and charge his EV
WHERE—At any location in the city, be it near his home or elsewhere when this problem occurs
WHY—This problem is important because when he needs to charge his EV, he needs the app to actually show him that the charging point is available to use—and not blocked by a non-charging car, or out of order
HOW—Wants to be able to reach this goals by CPS providers apps being able to show if a charger is blocked by a non-charging vehicle

Federico is a citizen living in a busy & high pressure parking area who needs the charging app to show him available charge points that are not being blocked by non-charging vehicles—because he does not want to waste his time driving to an unavailable charger.

Persona no. 3—Marie

Figure 30— Image (Shutterstock, n.d.)

WHO—A dedicated environmentalist
WHAT—Her pain point is that she cannot conveniently charge her car anytime and anywhere as she could with an ICE vehicle
WHEN—experiences this problem daily when she needs to charge her EV, especially after work when she has no guarantee that she will find a charger
WHERE—She experiences this near home, around the city and when driving to the countryside
WHY—This problem is important because she wants to be able to travel freely without worrying about her EV running out of power
HOW—Wants to be able to reach her goal by somehow having charging services be as easy and accessible as refueling ICE cars at a gas station

Marie is a dedicated environmentalist who needs charging an EV to be as easy & convenient as going to refuel an ICE vehicle at a gas station because she wants to conveniently be able to charge her EV anytime and anywhere without fearing running out of battery power.

Persona no. 4—Kristian

Figure 31— Image (Shutterstock, n.d.)

WHO—a single father with 2 young kids
WHAT—His problem is that he does not have access to chargers near his home
WHEN—He experiences the problem daily when coming home and needing to charge his car
WHERE—He experiences the problem by his home
WHY—This problem is important because he does not want to park inconveniently far away to charge his car—especially when with his kids
HOW—Wants to be able to reach his goal by somehow being able to request for more chargers to be made available near his home

Kristian is a single Father, with two young children, who needs accessibility to chargers near his home because he does not want to park his car inconveniently far away in order to charge it—especially when with his children.

Summary

Mapping out a problem statement for each persona helped to clearly define and articulate the users' pain points that need to be addressed through possible service design solutions— to be explored at the start of develop phase with the ideation aspect of the 'design thinking process', transitioning from the problem to the solution.

3.5.4 Conclusion of 'define phase'

⇒ The define phase combined user-centric service design tools and methods which included: personas & user stories; user journey maps and user problem statements. The aim was to zoom-in on users' experiences, facilitated by the empathy maps that had been created during the discover phase of the design process—and of the analyzed and synthesized data derived from: the field research 'quick & dirty' conversations; the mixed method survey and the semi-structured user interviews.

⇒ The creation of personas enabled context-specific representation of the majority of the service/product user base of urban dwellers who depend on on-street charging services for their charging needs (*Learn More about Personas | Coursera*, n.d.). These personas were based on the most common themes in the data, focused on user behaviors and of well-defined goals to meet their specific needs (ibid; Why Personas Fail, n.d.).

⇒ The personas were further defined with fictional one-sentence user stories from the point of view of each persona, illustrating everything we need to know about that persona. And the summarized user goals and frustrations formed the basis of creating user journey maps to help illustrate the possible steps, interactions and emotions of the users as they engage with the product/service or experience.

⇒ The user journey maps helped to provide a narrative to how users' may experience their end-to-end user experience with the product/service as they attempt to achieve their end goal— providing a holistic view at each point of contact (or touchpoint) and helping to identify their possible pain points and for opportunities for improvements.

⇒ Lastly, creating a problem statement for each persona helped to clearly define the users' pain points that can be addressed through possible service design solutions— explored at the start of develop phase (below section 4.3) with the ideation aspect of the 'design thinking process', transitioning from the problem to the solution.

3.6 Develop

The aim of the develop phase is to find answers to the problem statements to enable transitioning to finding a solution. The activities conducted in this phase included an initial ideation phase to hone in on the problem statement that needs to be solved. Following this ideation phase of the 'design thinking' process, a service solution was chosen and mapped out using various tools and methods to illustrate how the chosen problem statement could be solved. Lastly, low- and mid-fidelity prototypes were created and tested with users to see if the design solution is viable, or if it should be iterated upon.

This subchapter is divided into the following sections:

4.3.1 Ideation phase
4.3.2 Selected solution & goal statement
4.3.3 User flows
4.3.4 Storyboards
4.3.5 Low-fidelity paper wireframes
4.3.6 Mid-fidelity digital prototype
4.3.7 Usability testing
4.3.8 Conclusion of the develop phase

3.6.1 Ideation phase

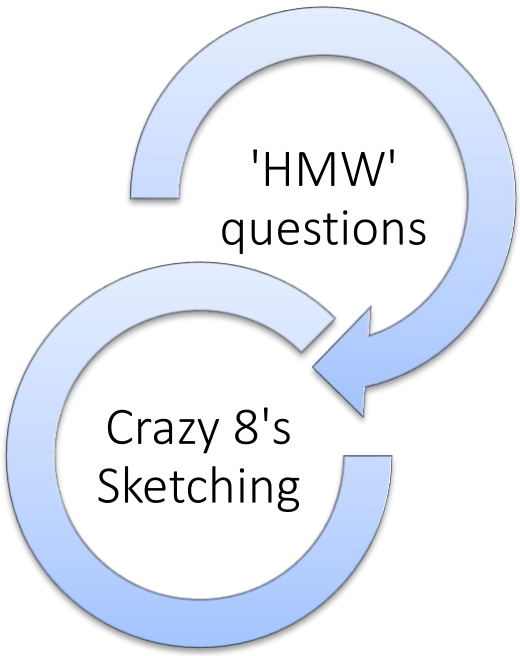


Figure 32—Visual of ideation phase process—self-made

The design ideation phase is the process of generating a broad range of ideas and without judgment to come up with as many ideas as possible (*Learn More about Design Ideation | Coursera*, n.d.-a). Ideation is all about generating ideas based on the insights gained during the discover and define stages of getting to know users and having clear problem statements (What Is Ideation? 2023 Guide To The Design Thinking Phase, n.d.). Having a well-defined problems that need to be solved, with the user's needs at forefront enables to think of a broad range of ideas to solve these. For the ideation phase, two complimentary methods were applied: 'How might we' ('HMW') questions and Crazy 8's sketching.

'How might we' (HMW) questions

'How might we' (HMW) questions are a way to brainstorm possible solutions to the clearly defined design problems—and one of the most common design methods for the ideation process as they enable a wide variety of solutions for users' problems to be addressed. (*Learn More about Design Ideation | Coursera*, n.d.-b). Thus to commence the ideation process—the HMW brainstorming session was focused on the clearly defined problem statements (section 4.2.3). This HMW brainstorming session (below fig. 33) enabled imagining possible different directions to further explore in order to address the EV users' clearly defined problems.

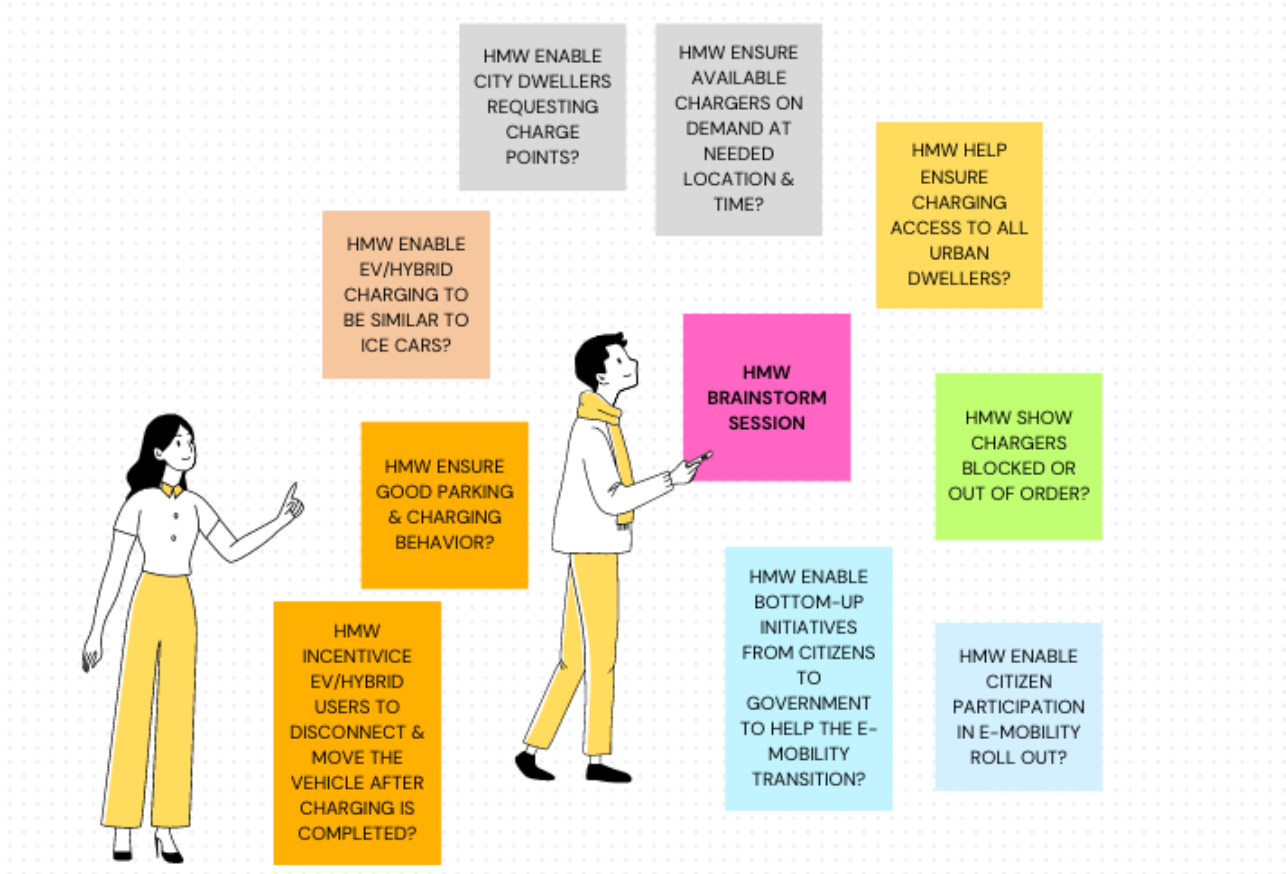


Figure 33—'HMW' brainstorming—self-made via Canva

The 'HMW' brainstorming session facilitated framing identified EV user problems in a way that encouraged ideation and exploration of different angles and perspectives—and provided ideas to further explore in the next ideation activity of Crazy 8's sketching.

Crazy 8's sketching

After the 'HMW' brainstorm session, the ideation process continued with Crazy 8's method. Crazy 8's is a method to generate lots of ideas in a short amount of time—within eight minutes to be specific, hence the method's name (*Best Practices for Crazy Eights | Coursera*, n.d.). In application, one sketches eight possible design solutions and with each sketch being a new idea that can solve the user's problem (ibid) based on a well-defined problem from 'HMW' questions—or from a well-defined problem statement, as had been defined in the define phase (section 4.2.3). Sketches are quick, inexpensive and flexible visualizations that allow for exploration—and are the first step in explorative prototyping (Stickdorn & Schneider, 2018). Commonly, sketches are done using pen and paper to make quick and low-fidelity visualizations of an initial idea or concept within seconds or minutes (ibid)—as is the case with the Crazy 8's sketching method. Thus, the benefit of applying Crazy 8's sketching is in being able to generate lots of ideas in a short period of time—and because of the short timeframe, it helps allows to think outside the box without having time for judgement (*Best Practices for Crazy Eights | Coursera*, n.d.).

Below (fig. 34-36) illustrate three Crazy 8's sketching sessions. Two of the sessions were based on 'HMW' questions generated in the initial brainstorming session (illustrated in above fig. 33). And one of the sessions was based on a clearly defined problem statement from section 4.2.3 of the define phase.

Session 1

'HMW' SHOW CHARGERS BLOCKED OR OUT OF ORDER?

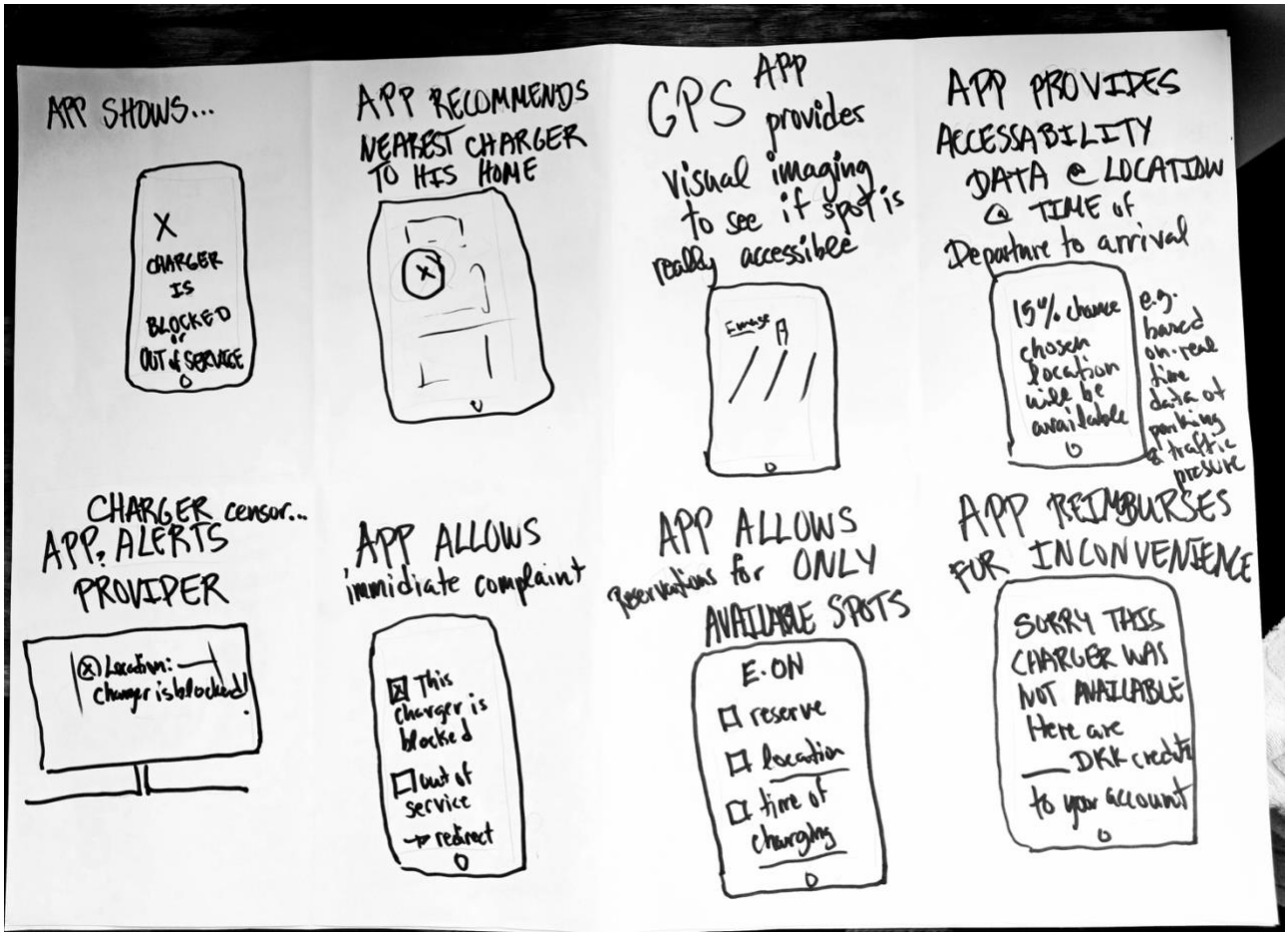


Figure 34—Crazy 8's ideation on 'HMW' show chargers blocked or out of order?

Description:

- App shows a charger is blocked or out of service.
- Charger censor alerts service providers that a charger is blocked in order for the charging service app to indicate this to users looking for available chargers.
- App recommends the nearest available charger near his home.
- App allows for an immediate complaint, such as a blocked charger.
- GPS provides real-time visual imaging to see if the charging spot is accessible.
- App allows for reservations of available chargers.
- App provides accessibility data of charger location at the estimated time of arrival to indicate the probability of the charger being available based on real-time data of parking and traffic pressure.
- App reimburses the user for the inconvenience of arriving to an unavailable charger by offering monetary credits to the user's account.

Session 2

Problem statement: Niels is a caring Father & Grandfather who needs a way to influence the national and/or regional government to build more CI because there is not enough of it to meet the charging needs of all in order to be able mass transition to e-mobility by 2030.

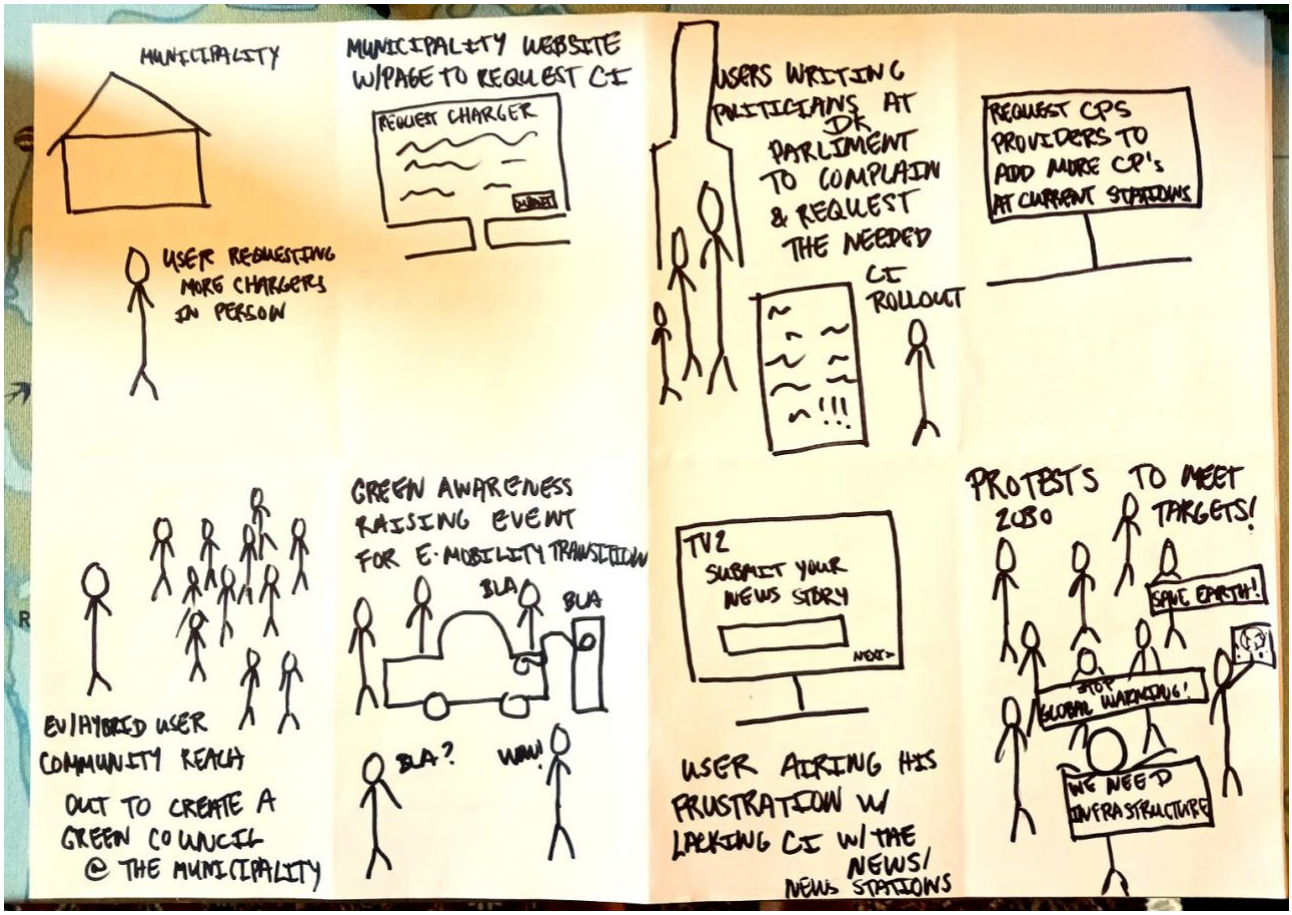


Figure 35—Crazy 8's ideation on Niels' problem statement

Description:

- User requests more chargers at the municipality in person.
- Users community reach out to create a green council at the municipality.
- Municipality website to request chargers where EV users relying on on-street chargers need them
- Green awareness raising event for transitioning to e-mobility.
- Users writing politicians at Denmark's parliament to complain about the lack of CI and to request the needed rollout for full development.
- Users airing frustrations about lacking CI with news/media for them to report it.
- A website enabling to request to add more charger points at current charging stations.

- Users protesting the need for more development to CI to meet 2030 emissions targets.

Session 3

'HMW' ENABLE CITIZEN PARTICIPATION IN THE E-MOBILITY ROLL OUT?

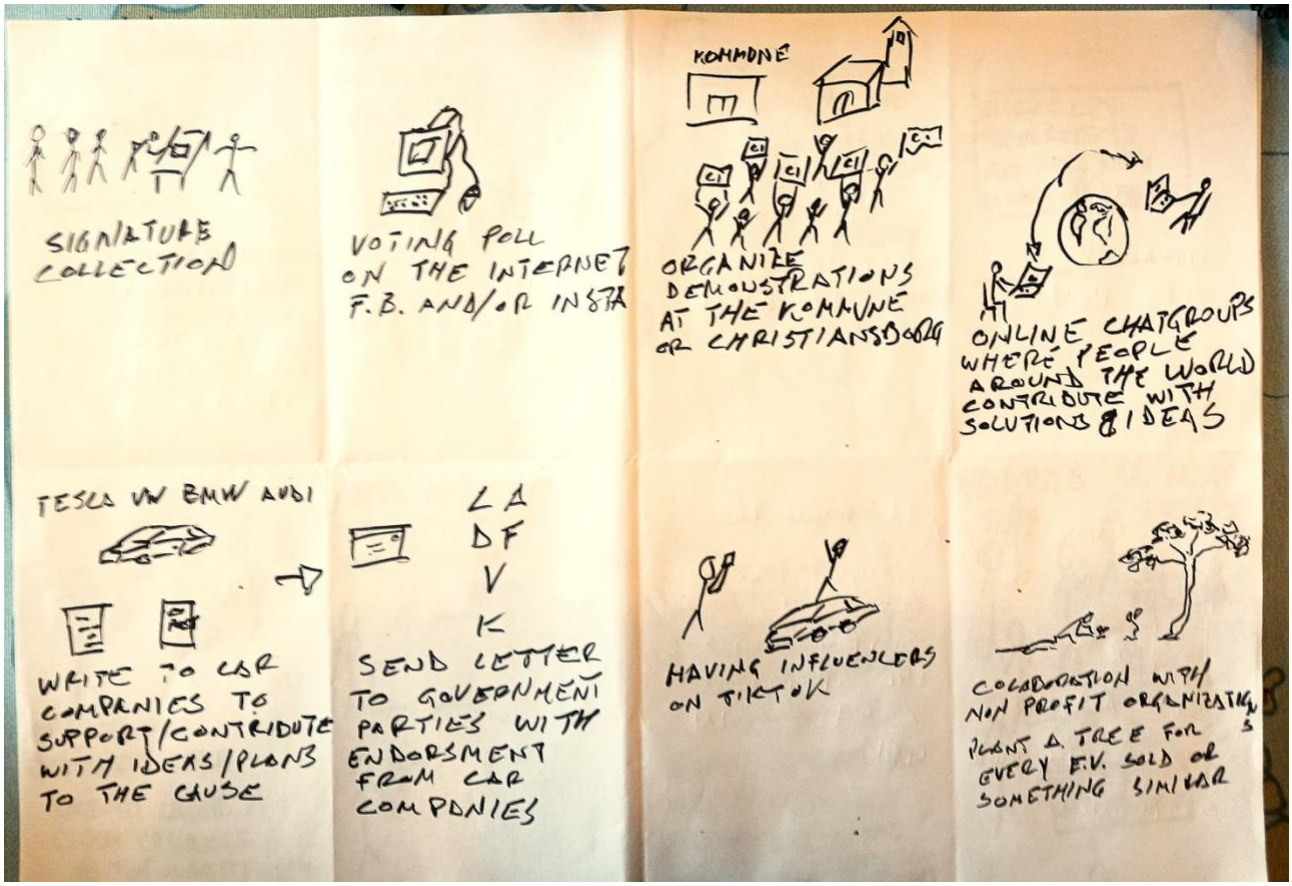


Figure 36—Crazy 8's ideation on 'HWM' enable citizen participation in the e-mobility roll-out?

Description:

- Signature collection for e-mobility roll-out.
- Contacting car companies to support/coordinate ideas and plans for CI roll-out.
- Voting poll on the internet, e.g., through social media.
- Sending letters to parties in the government that support e-mobility roll out with the endorsement of EV car manufacturers.
- Users organizing demonstrations at the municipality or at Kristianborg.
- Having influencers on social media such as TikTok to endorse citizen participation in e-mobility roll-out.
- Online chat groups where people around the world can contribute with ideas and possible solutions.

- Coordination with non-profits for planting a tree for every EV sold, or something similar such as with charging stations built.

Preliminary reflections of the ideation phase

1. The 'HMW' brainstorming session facilitated framing identified EV user problems in a way that encouraged ideation and exploration of different angles and perspectives—and provided ideas to further explore in the ideation activity of Crazy 8's sketching.

2. Crazy 8's sketching, being a time constrained activity to generate eight rough sketches, allowed for divergent thinking as one must quickly explore various possibilities without getting attached to one idea. And sketching ideas helped quickly visualize possible service solutions.

3. The structured nature of 'HMW' questions and the time-constrained sketching of Crazy 8's helped to overcome creative blocks by providing clear guidelines and constraints thereby providing a framework that helped to spark creativity.

4. Overall, combining 'HMW' questions with Crazy 8's sketching in the ideation process encouraged expansive thinking—with multitudes of ideas—fostering innovative thinking and the generation of a diverse set of user-centric solutions.

3.6.2 Selected service solution

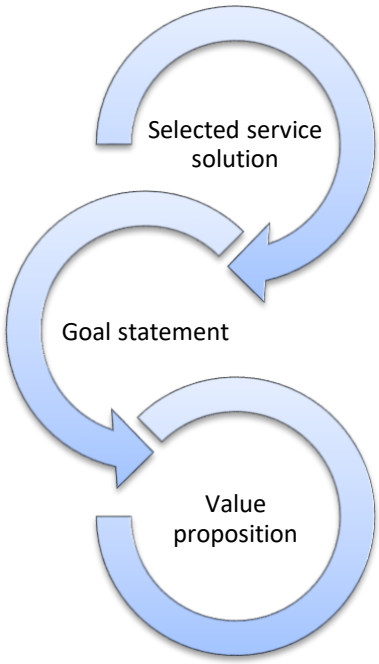


Figure 37—Visualization of the selected service solution process—self- made

Upon completing the ideation phase, the next step was in choosing one of the ideated service solutions from the Crazy 8's sketching sessions. In order to choose a service solution, three key identified user research pain points were taken into account: blocked or out of service chargers, EV users' staying idly plugged-in after their vehicle is fully charged, and the lack of public CI. The selected service solution—which has the potential to address all three of these pain points (below fig. 38)–is an app for urban EV users to reserve chargers when and where they require to be created by an EV app service provider in collaboration with Copenhagen municipality as a *public-private partnership* (PPP). In much the same way the municipality already collaborates/work with other private companies, such as those offering apps to drivers to pay for on-street parking on municipal roads.

As a case in point, the conducted literature review illustrated the fact that the current business model for EV development is not sustainable in order to address that lack of public CI and of its services. However, various studies have shown that new innovative business models that can connect the private and public sectors through public-private partnerships (PPPs) can facilitate the necessary development of public CI and of its services. Yang et al. (2016) and Wang and Ke (2018) found that PPPs are an effective way to accelerate EV development as PPPs offer a way to access the private sector's resources and professional skills, while easing the burden for municipalities. PPPs enable achieving a 'win-win' situation where the public and private sectors can share both risks and costs and thereby enhance mutual project management and profitability (Hall, 2017; Kneeshaw, 2012). Thus it was deemed that this service solution could offer the potential for the EV service company to bring its resources and expertise within EV services and infrastructure—while the municipality would bring their own resources and capabilities such as through policy that ensures that chargers are for reserved charging vehicles only.

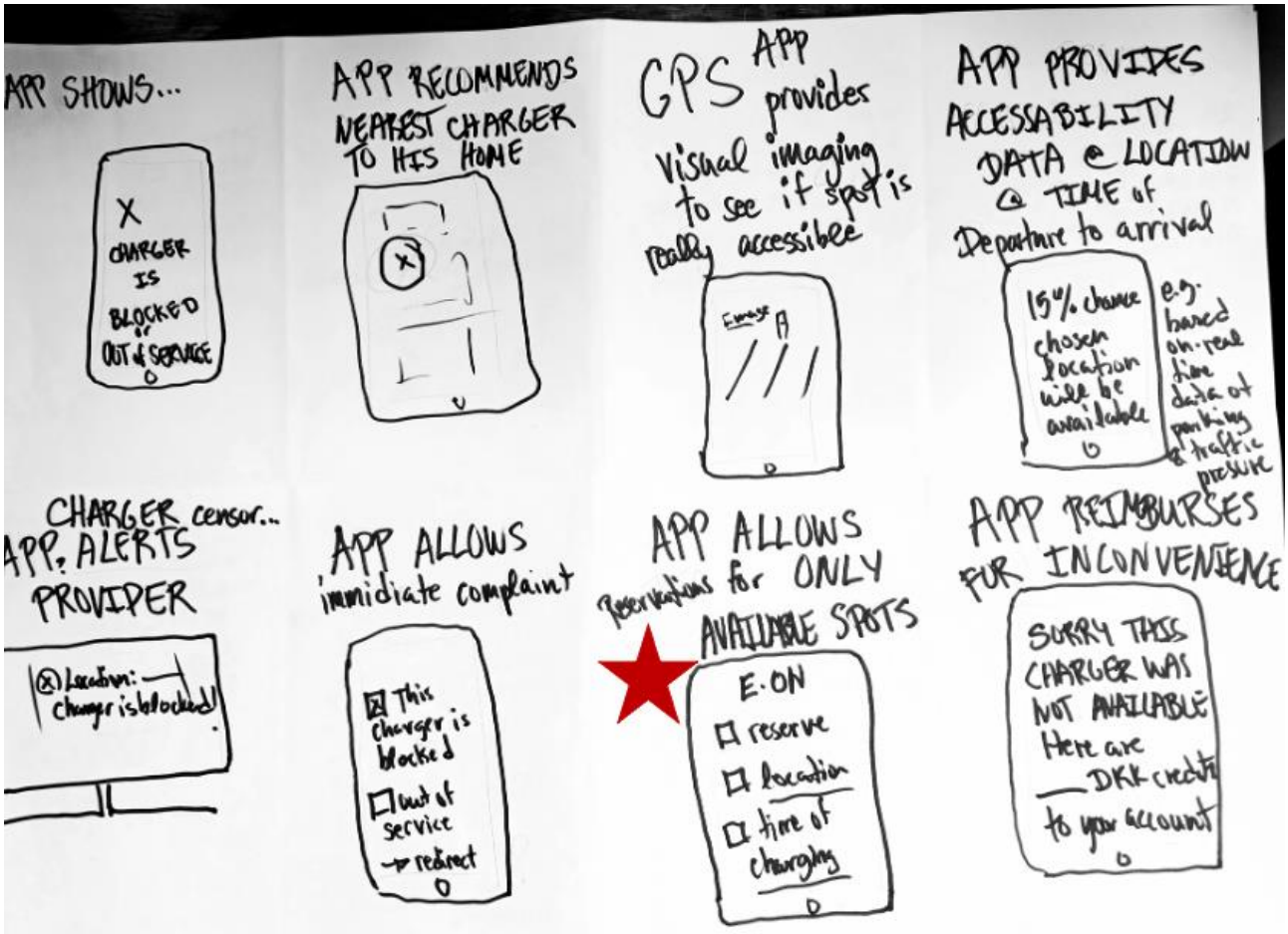


Figure 38—Selected service solution—app for making reservations for chargers where and when needed

Having selected the above ideated service solution (fig. 38), the next step is to identify a goal statement and value proposition to ensure a comprehensive understanding of the service solution's purpose, objectives and of its benefits to the end-user. A goal statement provides strategic direction and defines the problem to be solved, while the value proposition communicates the unique value and advantages of the solution to the target audience—here being urban dwellers relying on on-street charging services to fulfill their EVs charging needs (*Determine a Value Proposition | Coursera*, n.d.; *Learn More about Goal Statements | Coursera*, n.d.).

Goal statement

A goal statement illustrates the transition from the problem to the found service solution. Goal statements are brief one to two sentences that describe the product/service solution and its benefit to the user (*Learn More about Goal Statements | Coursera*, n.d.). Goal statements describe what the product/service will do, who this will affect and what positive impact this will have on solving the user's need(s) (ibid). The goal statement for the selected service solution is the following:

This app will allow EV users to reserve chargers, which will affect urban EV drivers who need to charge their vehicle by being able to reserve chargers when and where they need them.

Having defined the above goal statement—the next step is to distinguish this solution's value proposition. That is, what value will EV users get from using this app, and how will it solve their problem (*Determine a Value Proposition | Coursera*, n.d.)

Value proposition

A value proposition describes why a consumer should use a product or service by making it clear what the product/service provides users, as well as why users should care (i.e., what problem is the product/service solving) (ibid). Below (table 3) lists the app features and the pain points these features will help to solve for urban EV users—followed by the value proposition.

What will the app do?	*What pain point will it solve?*
The app will only show chargers that are available for booking	Blocked, our out of service, charge points
The app will offer charging time slots that are 2-hours maximum. EVs that remain plugged-in beyond their booked charging reservation time will incur a fee for every minute they stay idly plugged-in	This will address EV users that stay idly plugged-in after their vehicles are fully charged, thus making chargers inaccessible to other EV users
The app will allow EV users to book a charger when and where they require it	This will address the insufficient on-street CI, as now chargers can be reserved for a specific period of charging time thereby enabling more availability and accessibility for all to charge their EVs

Table 3—Apps features & addressed pain points—self-made

One of the most important things about value propositions is that they need to be short clear and to the point so users can easily identify how this service/product will meet their needs (Determine a Value Proposition | Coursera, *n.d.)*. The following is the value proposition for this charging reservation app:

> *This app will provide urban EV users with the assurance that they will be able to find and book an accessible charger when and where they require one to fulfill their charging needs.*

Summary

⇒ In order to choose a service solution, three key identified user research pain points were taken into account: blocked or out of service chargers, EV users' staying idly plugged-in after their vehicle is fully charged, and the lack of public CI.

⇒ The chosen service solution has the potential to address these pain points as a reservation app for on-street chargers created via a PPP between Copenhagen municipality and the EV service provider. This app will allow EV users to reserve chargers, in much the same way apps currently offer drivers a way to reserve and pay for on-street parking on municipal roads. This service solution will positively affect urban EV drivers who rely on on-street chargers by allowing them to reserve chargers when and where they require them—and with the assurance that these chargers will be accessible (i.e., not blocked by non-charging vehicles, or in being out of service).

3.6.3 Storyboards

Following the selection of the chosen service solution, storyboards were sketched to visualize how this app could be experienced by an urban EV user. Storyboards are a series of frames that visually explore a user's experience with a product or service—telling a story of the user, of the given environment the user is in and with a narrative that illustrates a problem the user is encountering and how the design will solve this (*Learn More about Creating Storyboards | Coursera*, n.d.). There are two types of storyboards: 'big picture' which is user focused and 'close up' which is product/service focused (ibid)

Below (fig. 39 & 40) will explore both storyboard types, starting with the 'big picture' user focus and then zooming into the 'close up' product/service depiction of the reservation app.

'Big Picture'

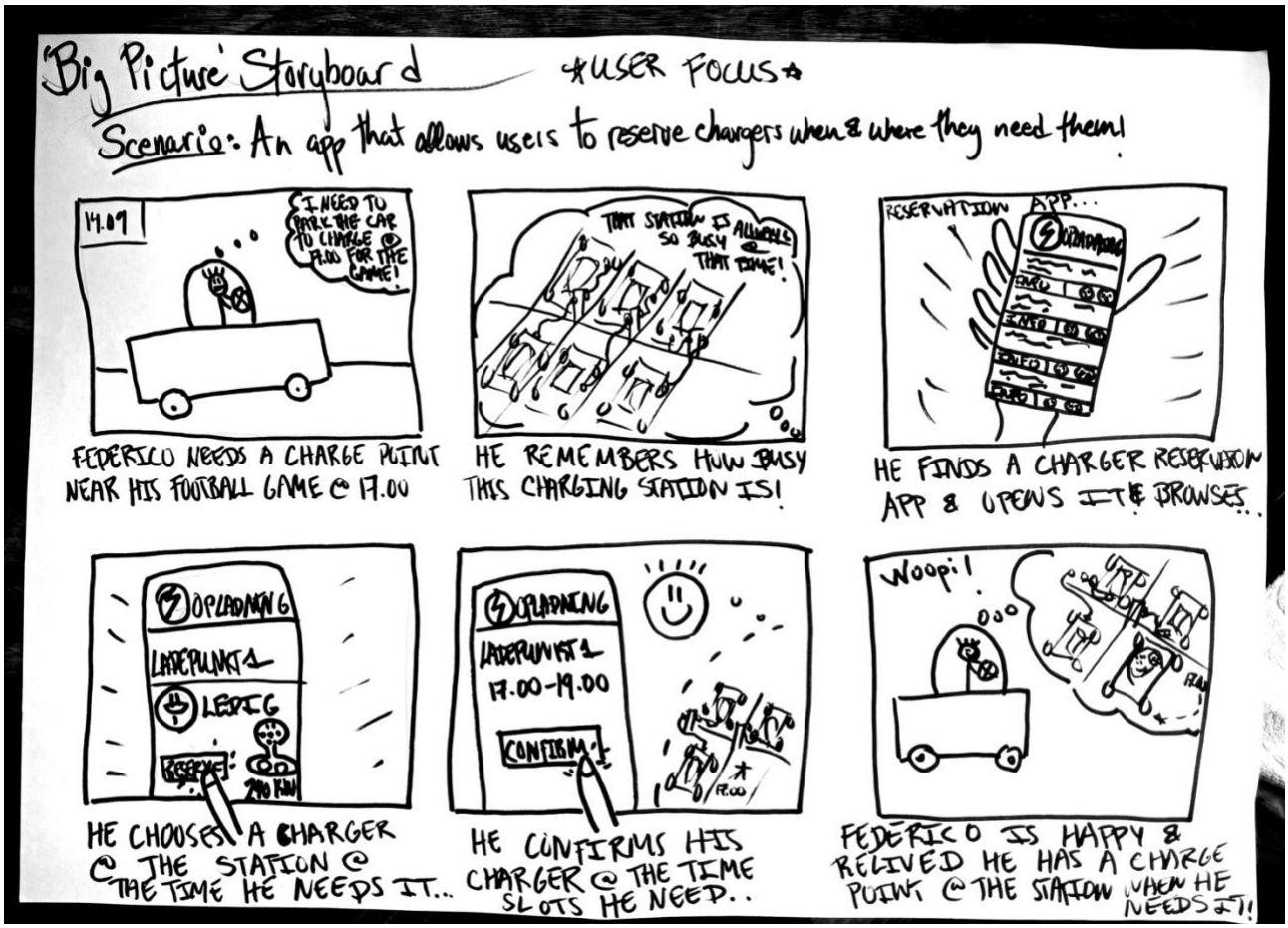


Figure 39—'Big Picture' user focus of an app allowing users to reserve chargers when and where they need them—self-made

Description:

1. In the first panel, the user Federico remembers he needs a charge point near his football game, which starts at 17.00.
2. In the second panel, Federico is stressed as he remembers how busy that charging station near the football field tends to be at this time of the day.
3. In the third panel, Federico opens his phone to find a charge point reservation app, and he browses through it to find the charging station he needs.
4. In the fourth panel, he chooses an available charger and at the time he needs it.
5. In the fifth panel, Federico confirms his charger reservation between 17.00-19.00.
6. In the last panel, Federico is happy and relieved he has a charger when and where he needs it.

'Close up'

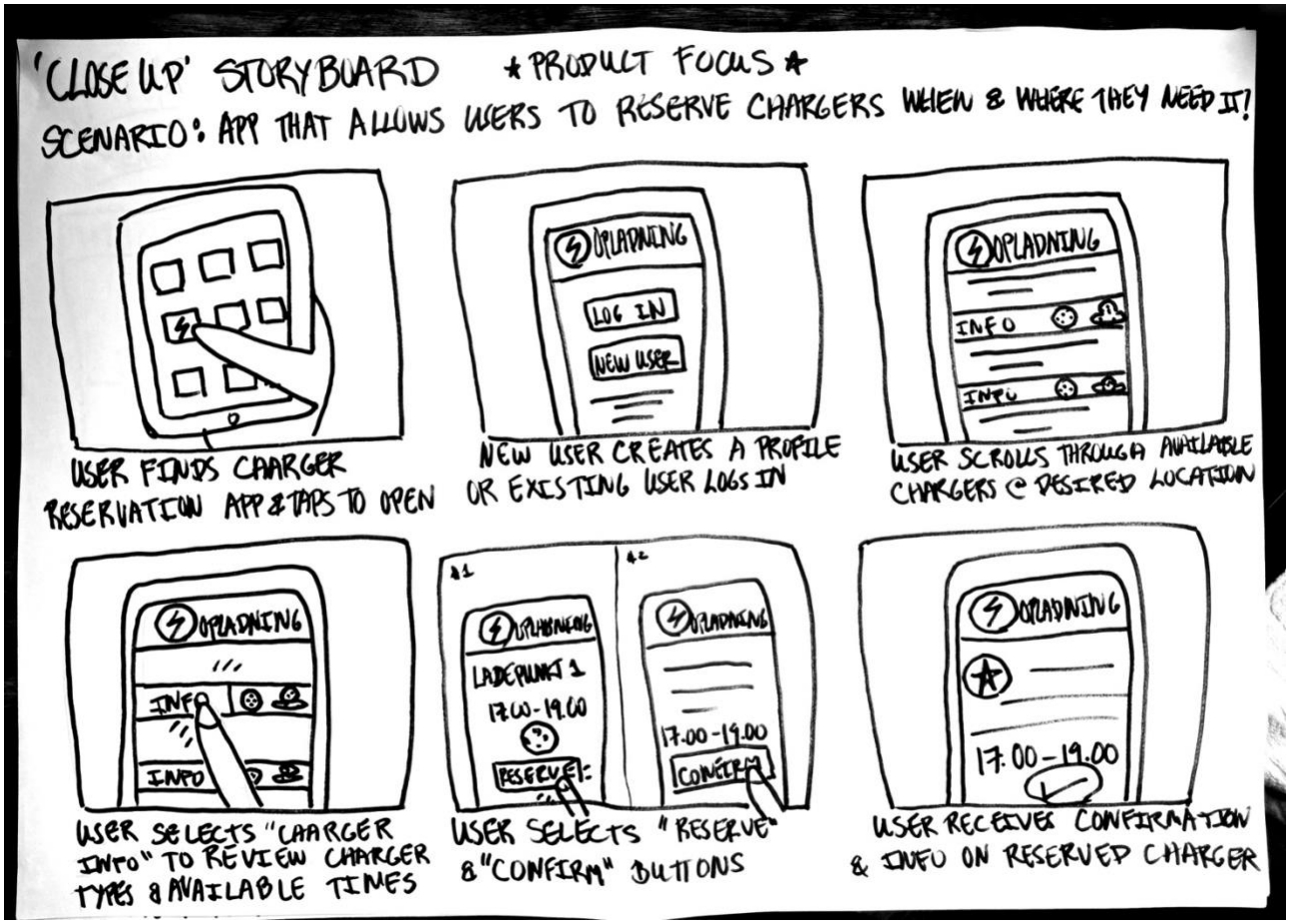


Figure 40—'Close up' product focus of an app allowing users to reserve chargers when and where they need them—self-made

Description:

- In the first panel, the user opens their phone, swipes through their apps and taps on the charger icon to open the app.
- In the second panel, the focus is on how the user begins their journey when they first open the app. Here a new user can create a new profile and an existing user can sign in.
- In the third panel, once the user has logged in, they begin searching for available chargers at the location they need.
- In the fourth panel, the user taps on 'info' about a charger and on available charging times.
- In the fifth panel, the user has found the charger and time they need it and taps to reserve.
- In the sixth panel, the user receives confirmation of the reserved charger and information pertaining to the charger and its location.

Summary

Having applied storyboards helped to visualize the user journey and of the possible interactions with the chosen service solution reservation app. The 'big picture' provided an overview of the entire user journey, with the service solution app—which helped to understand the user experience holistically. While the 'close up' storyboard zoomed-in on the service app's functionality, focusing on specific interactions and user tasks within it. Utilizing both 'big picture' and 'close-up' storyboards, after choosing the service solution, helped to provide a full understanding of the user journey.

3.6.4 User flow

Following the storyboards a user flow was mapped out for the reservation app. User flows (or flowcharts) are used to visualize and map out the sequence of steps a user takes to accomplish a specific task within a digital product/service (*Wireflows: A UX Deliverable for Workflows and Apps*, n.d.-a). They describe both the back-end processes and user task flows (ibid). User flows provide a detailed representation of the user's journey, mapping out the path they follow, actions they take and decisions they make (ibid). In user experience (UX) design, designers typically outline user flows with common shapes that include: circles, rectangles, diamonds, lines and arrows—and each shape represents an interaction the user will have with the product/service being designed (ibid). Illustrated in below fig. 41.

Figure 41—User flow shapes (ibid)

Description (ibid):

- Circles represent actions users take.
- Rectangles represent the screens of the digital product/service the user will experience while completing tasks.
- Diamonds represent points where the user must make a decision. The decision made will move the user forward through the flow or back to an earlier part of the flow.
- Lines and arrows tie everything together and illustrate the flow. Solid lines represent forward direction while dotted lines represent a backward direction.

The below (fig. 42) user flow was created to illustrate the sequence of steps a user might take to accomplish reserving a charger for their vehicle. The first action taken is for the user to open the app. This action brings the user to the app homepage. At the homepage, the user's next action is to select 'browse chargers'. After this action, the user arrives at the 'chargers' screen. After browsing for chargers, the user selects a charger where and when they need it. A screen follows showing available charging times for the selected charger. Next the user must decide either to book the selected charger, or to go back to selecting another charger. If the user chooses to book the charger, the next screen would display a confirmation for the reserved charger.

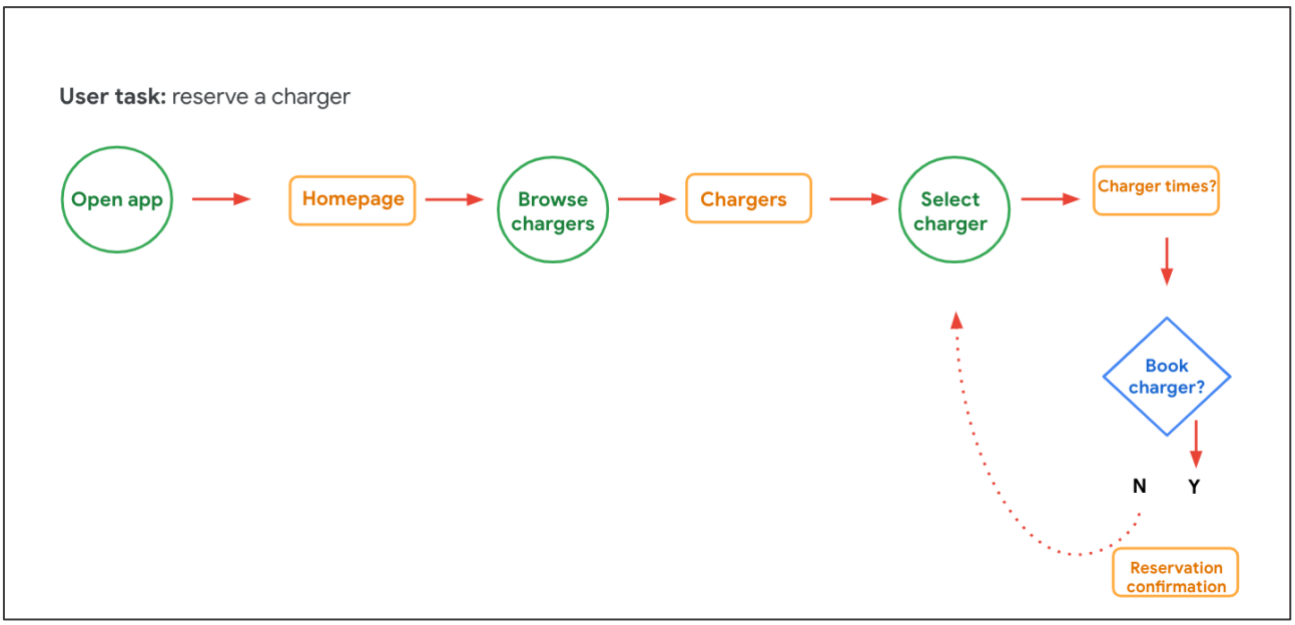


Figure 42—Reserving a charger flowchart—self-made via Google Slides

Summary

Having applied this user flowchart helped to identify the user's step-by-step progression through the reservation service app—of the possible paths the user may take—and of the overall structure of the digital experience. Having this user flowchart now provides a clear blueprint for creating low-fidelity prototypes.

3.6.5 Low-fidelity prototype wireframes

Following the user flow, the next step was the creation of low-fidelity wireframe prototypes. A prototype can represent a service concept as a physical or digital prop in the form of wireframes and mockups (Stickdorn et al., 2018). What is more, a prototype facilitates designers ability to test—or to walkthrough—the service concept step-by-step with the target users in order to gain valuable feedback before continuing to the final design (ibid). User flowcharts provide a high-level view of how users navigate through a product/service interface, focused on sequence and logic of user interactions—while wireframes visually represent the layout, structure and functionality of individual screens (*Wireflows: A UX Deliverable for Workflows and Apps*, n.d.-b). Low-fidelity wireframes show a simple user task with the use of screen designs rather than the abstract shapes used for user

flowcharts (ibid). Wireframes are a common practice for designing mobile apps where each step of the previous user flow chart is represented by a wireframe for a full mobile-screen design (ibid). A wireframe basically outlines the basic structure of the app's home screen and its functions—and it helps to understand the user's tasks when interacting with the service app. The benefit of low-fidelity wireframes is that they are fast, inexpensive and allow for the exploration of various ideas (*Introduction to Wireframes | Coursera*, n.d.). Below fig. 43-44 illustrates the user task of the first time using an app for reserving chargers for their EV.

Legend (ibid):

- ⇒ Body text is represented with horizontal lines
- ⇒ Images, photos, illustrations are represented by squares with a large X drawn on top
- ⇒ Call-to-action buttons, such as 'submit' or compose, are represented by rectangles or circles

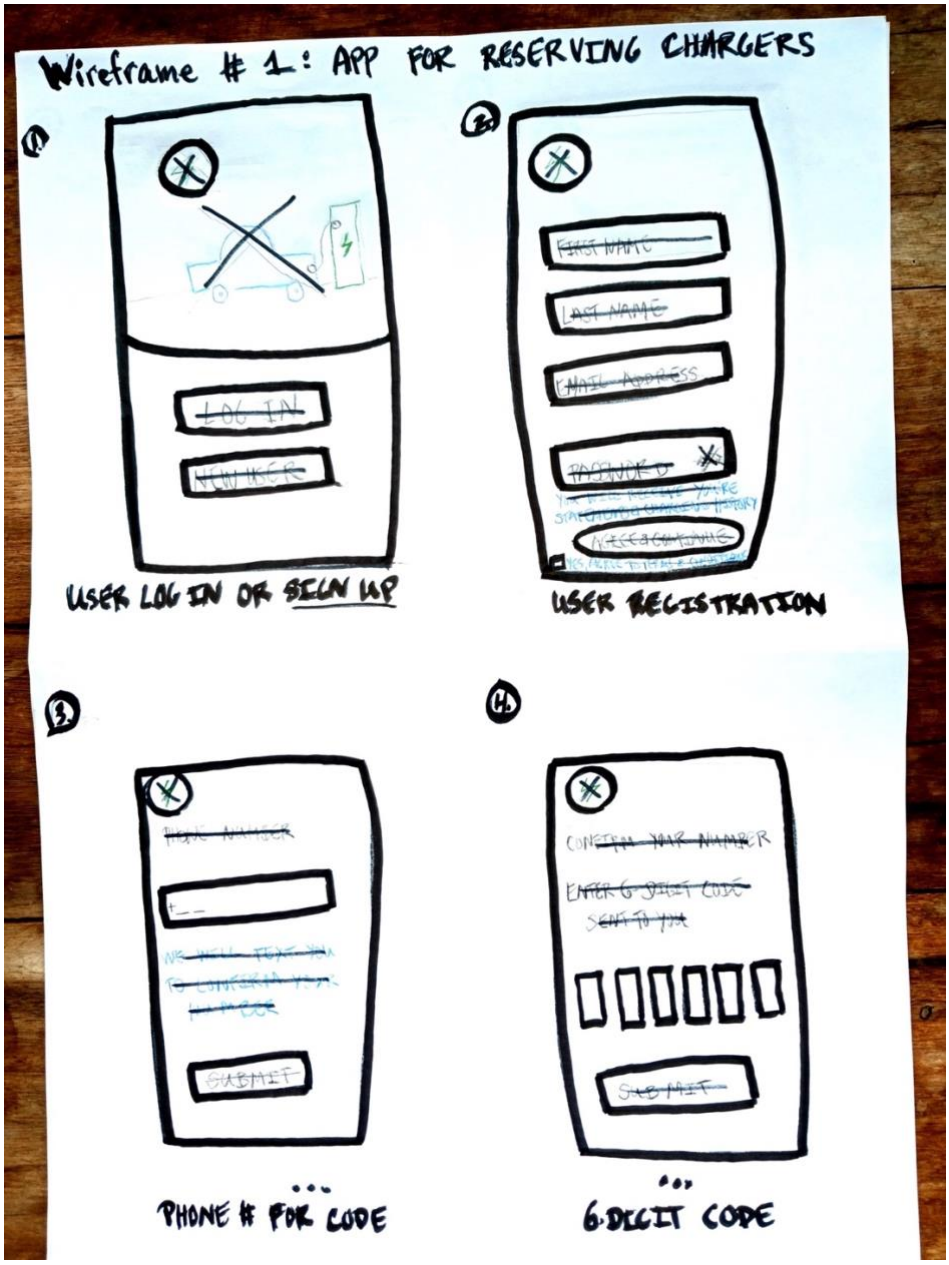


Figure 43—Wireframe of app for reserving chargers—self-made

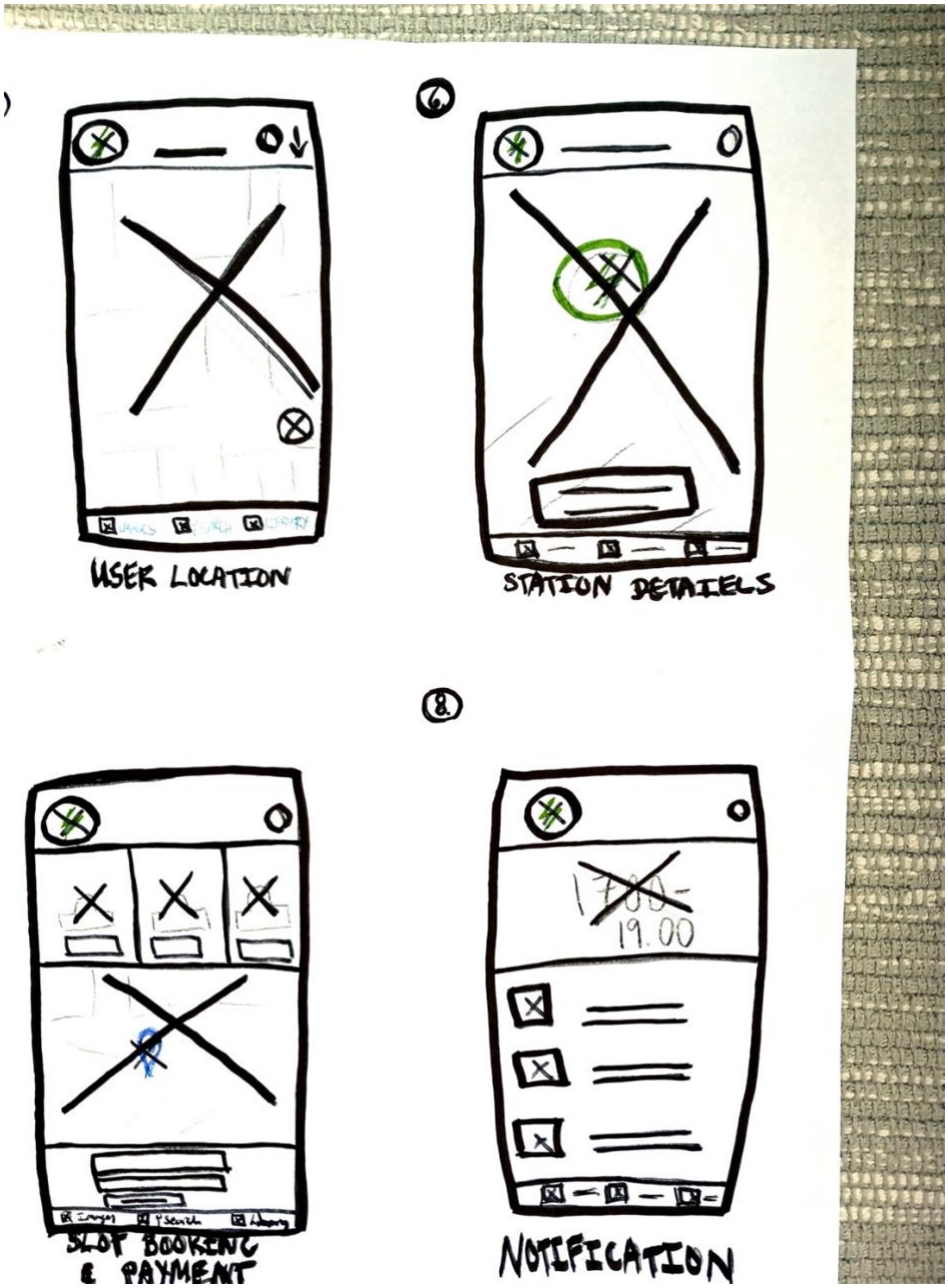


Figure 44— Wireframe of app for reserving chargers—self-made

Description:

⇒ The user has entered the charging reservation app and is at the homepage where one either log's in, if already a user, or signs up as a new user.

⇒ After selecting to sign up as a new user, the next screen shows the user registration screen that must be filled out and submitted.

⇒ In the third screen, the user must enter a phone number to receive a confirmation code.

⇒ After the user submits their phone number, they are taken to a confirmation screen where they must enter and submit the 6-digit code they receive to their mobile number.

⇒ Once the user 6-digit code is confirmed, the user arrives at a GPS homepage that shows his real-time location. Here at the bottom of the screen the middle icon show him a search option to find the location he is looking for to charge his vehicle.

⇒ After selecting the desired location, the screen zooms into the location and offers charging stations details.

⇒ In the next screen the user has selected the charging station and can now view the available charger options to reserve, with booking times and payment option to reserve.

⇒ Lastly, after the user has selected a charge point at the time they require and payment, in the next screen the user receives confirmation of their reservation with details about the charger and location of the charging station.

Summary

This low-fidelity prototype served as a simple representation of the reservation app's layout and functionality—outlining the basic structure of the app's home screen and its functions. Applying it helped to better understand what the user's tasks would be interacting with the app. The benefit of applying this low-fidelity paper wireframe was that it was quick, inexpensive and it allowed for exploring various ideas (*Introduction to Wireframes | Coursera*, n.d.). The next step will be the creation of a digital prototype, based on this low-fidelity wireframe, in order to provide a more realistic experience of the app's functionality which can then be tested on EV users.

3.6.6 Digital mid-fidelity prototype

In having the low-fidelity prototype as a representation of the app's functionality and layout, a digital mid-fidelity prototype was developed utilizing Figma software—created in collaboration with consulting UX graphic designer, Astrid K. Hansen. Figma is a prototyping tool that enables the creation from low-, mid-, to high-fidelity prototypes. It is a great tool to explore the possibilities of the product/service both visually and for testing purposes. The low-fidelity wireframe sketches provided the foundation to creating a mid-fidelity digital prototype in Figma. sMid-fidelity digital prototypes are a type of prototype with limited functionality but with several clickable areas representing the app's interactions and navigation potentials (*Everything You Need to Know About Mid Fidelity Prototype*, n.d.) Mid- fidelity digital prototypes aim to simulate key app interactions that rely on simple versions that save time and effort during the design process (ibid). Below fig. 45-53 illustrate the process a new user would go through screen-by-screen as they sign up for the reservation app and proceed to finding and reserving an available on-street charger. Here each frame view of the app was based on the chosen user journey for the selected service app concept.

This prototype is also accessible to view at this link:
https://www.figma.com/file/R90mW1wePmiMGSbmSO2VWr/Elisa-app?type=design&node-id=0-1&t=CfPGYkBTFAoeuJ8e-0

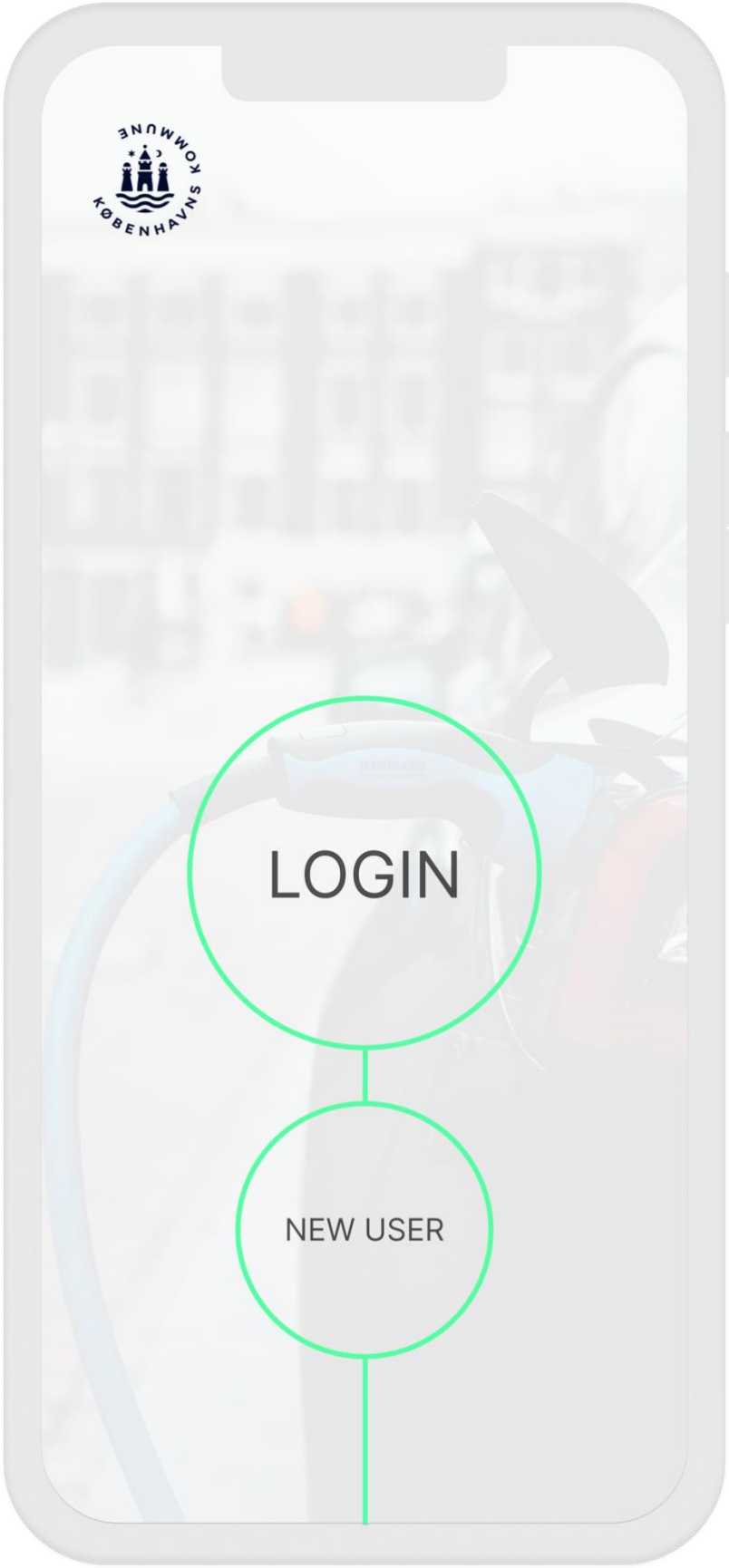


Figure 45—Log-in page

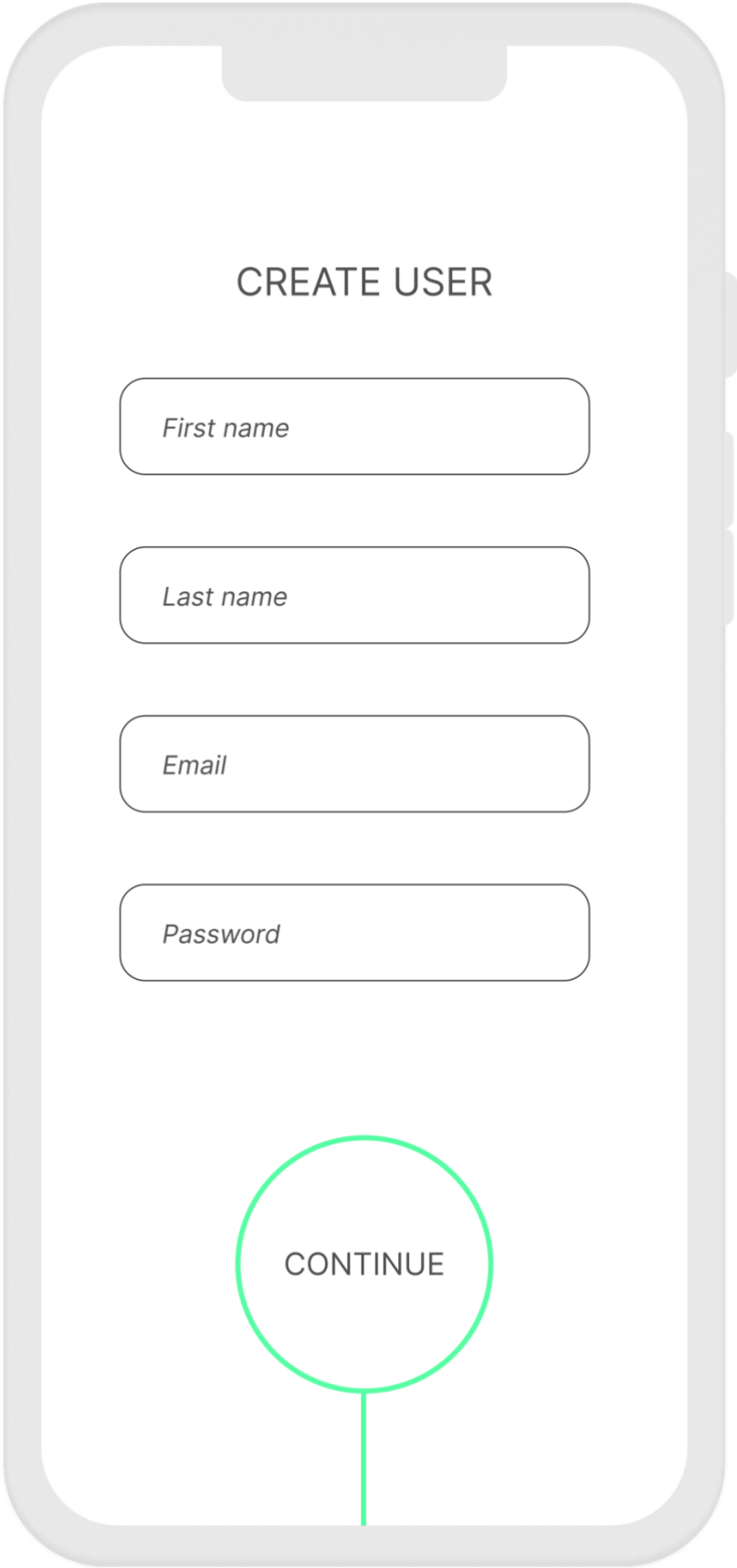


Figure 46—Create user page

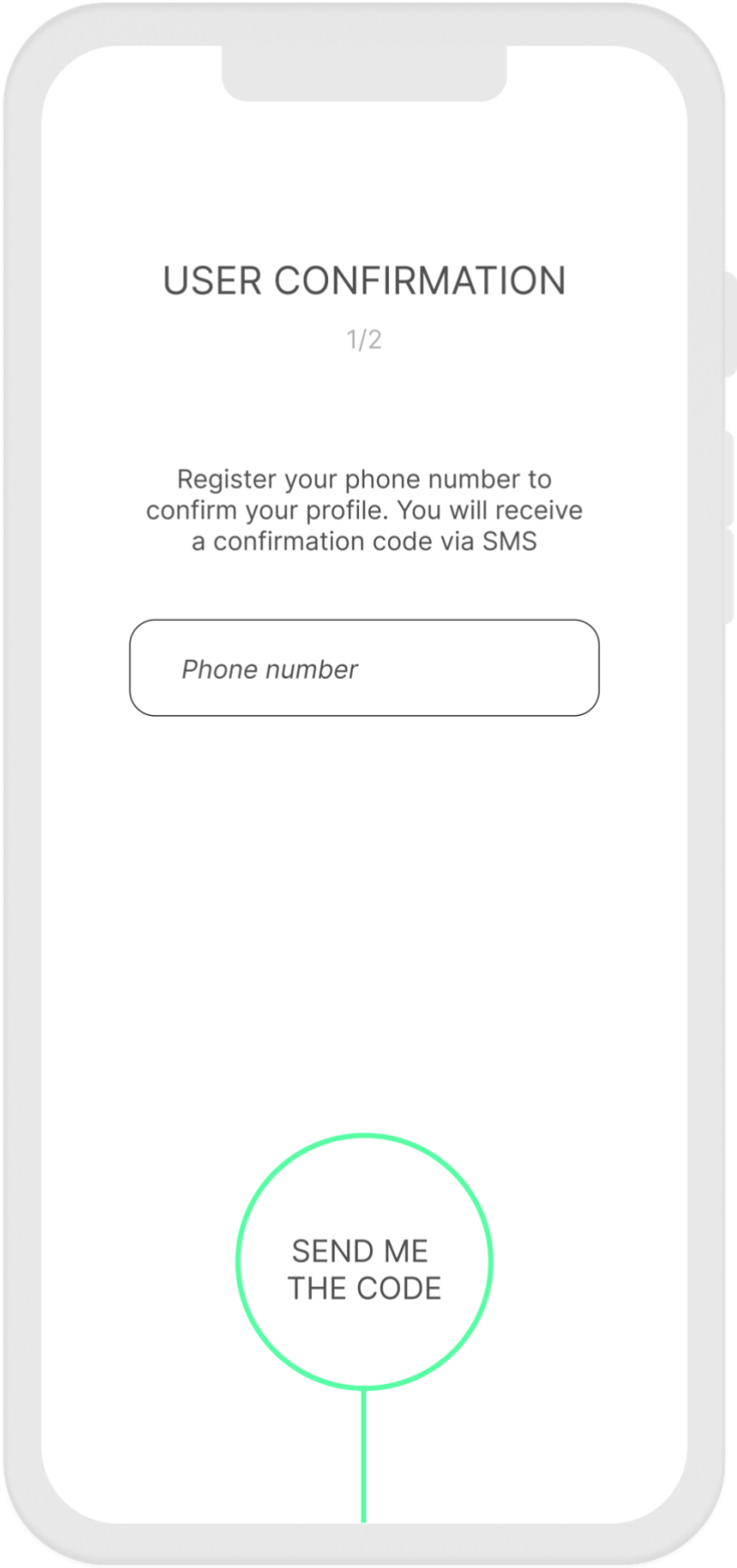


Figure 47—User confirmation via mobile number

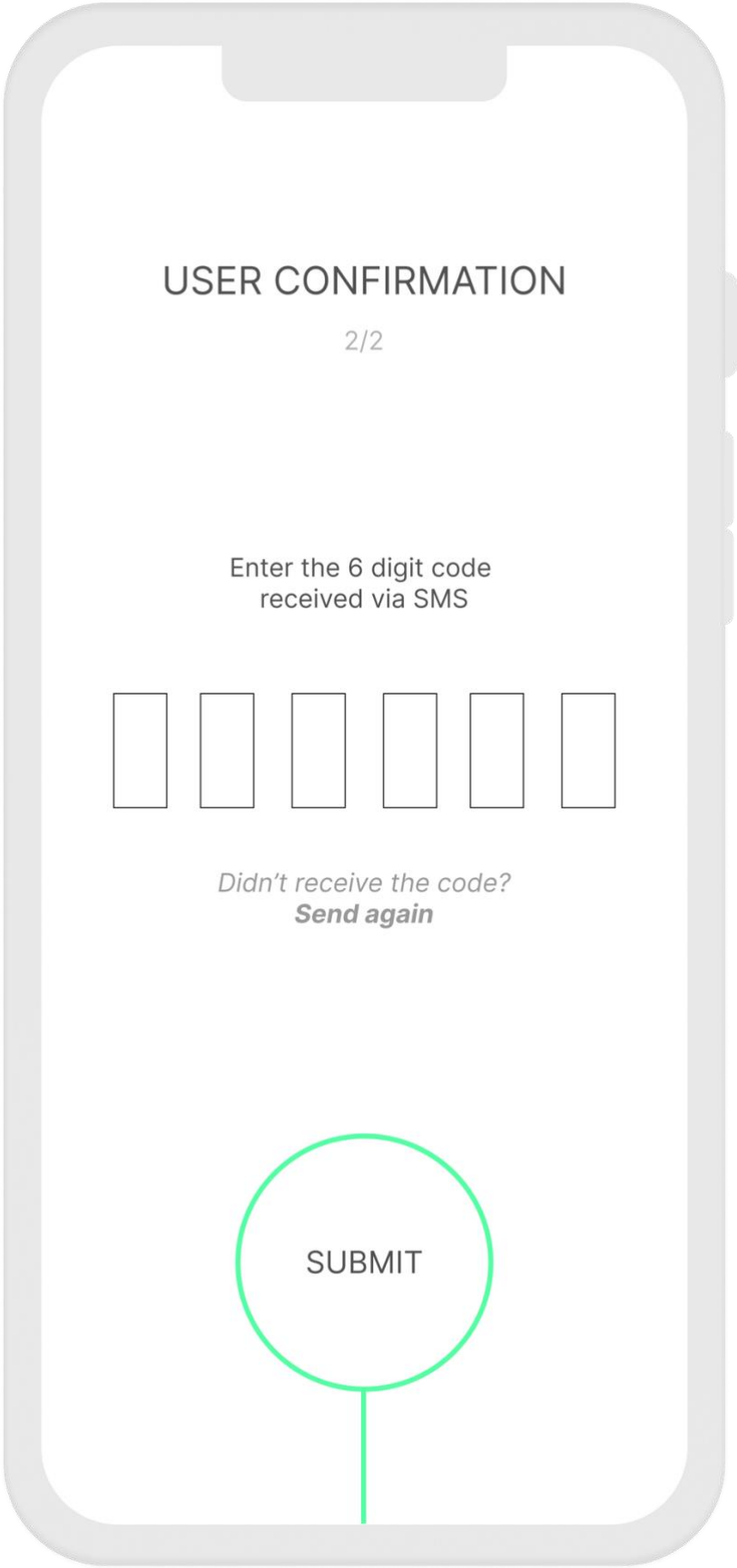


Figure 48—User confirmation code input

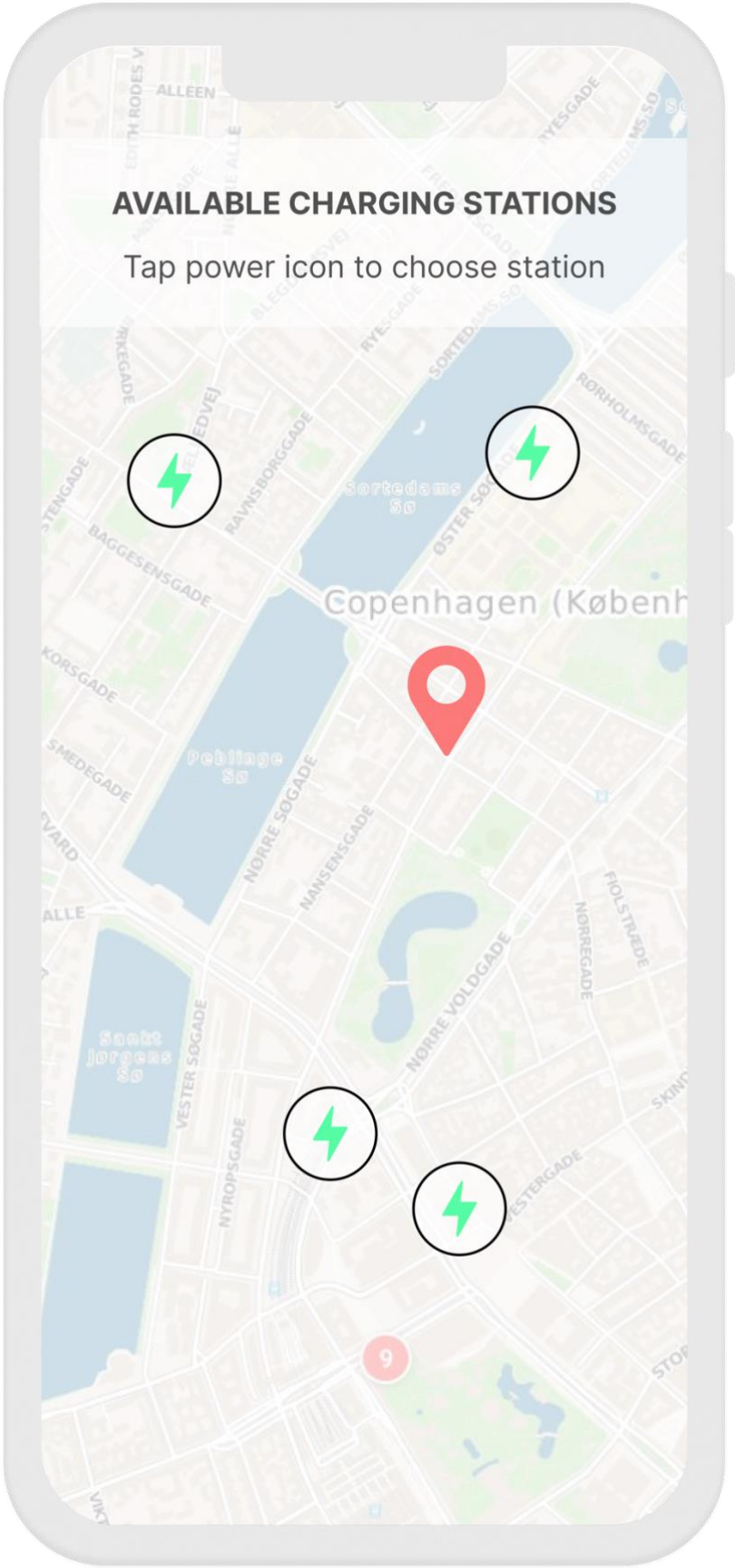


Figure 49—User GPS location & available charging stations

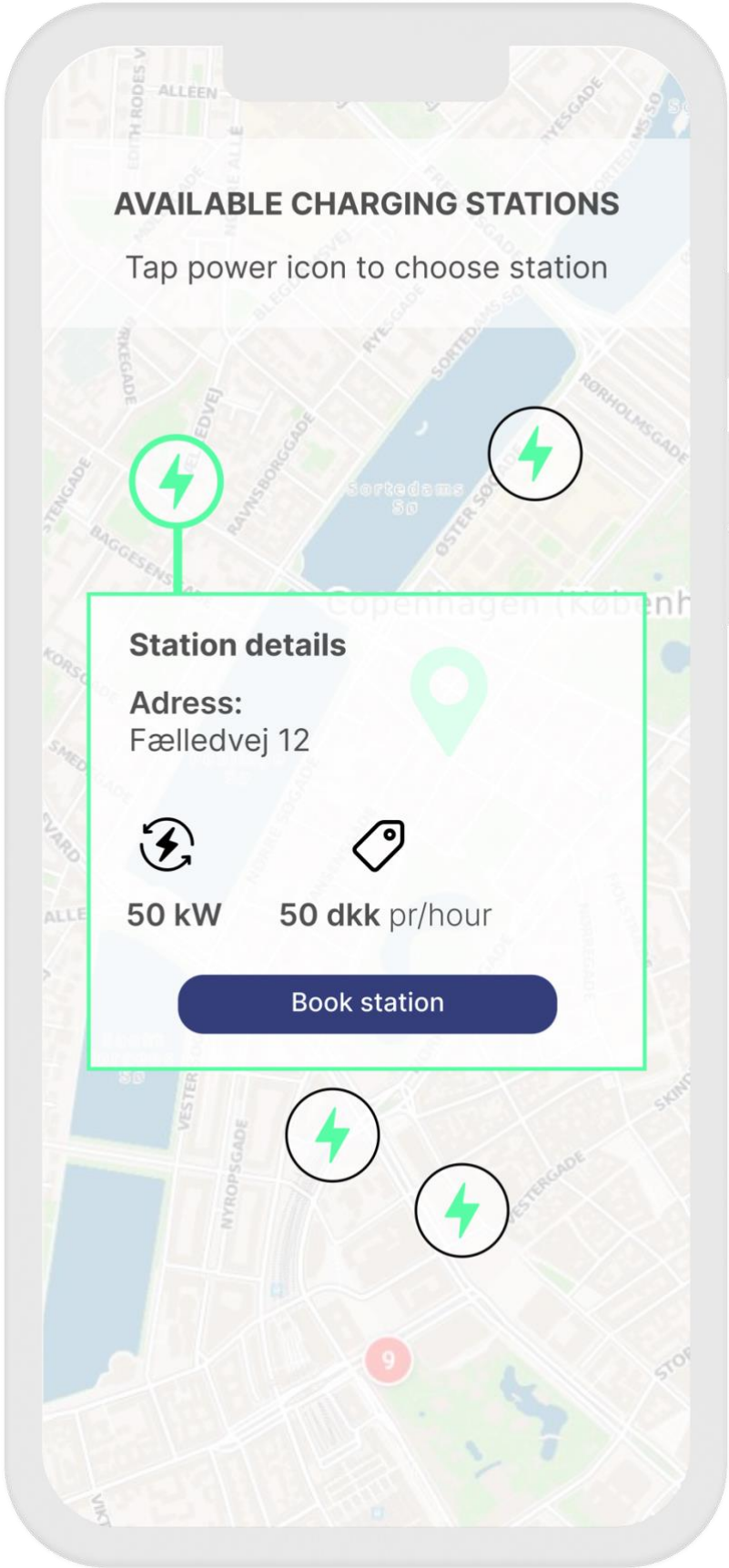


Figure 50—Charging station's details

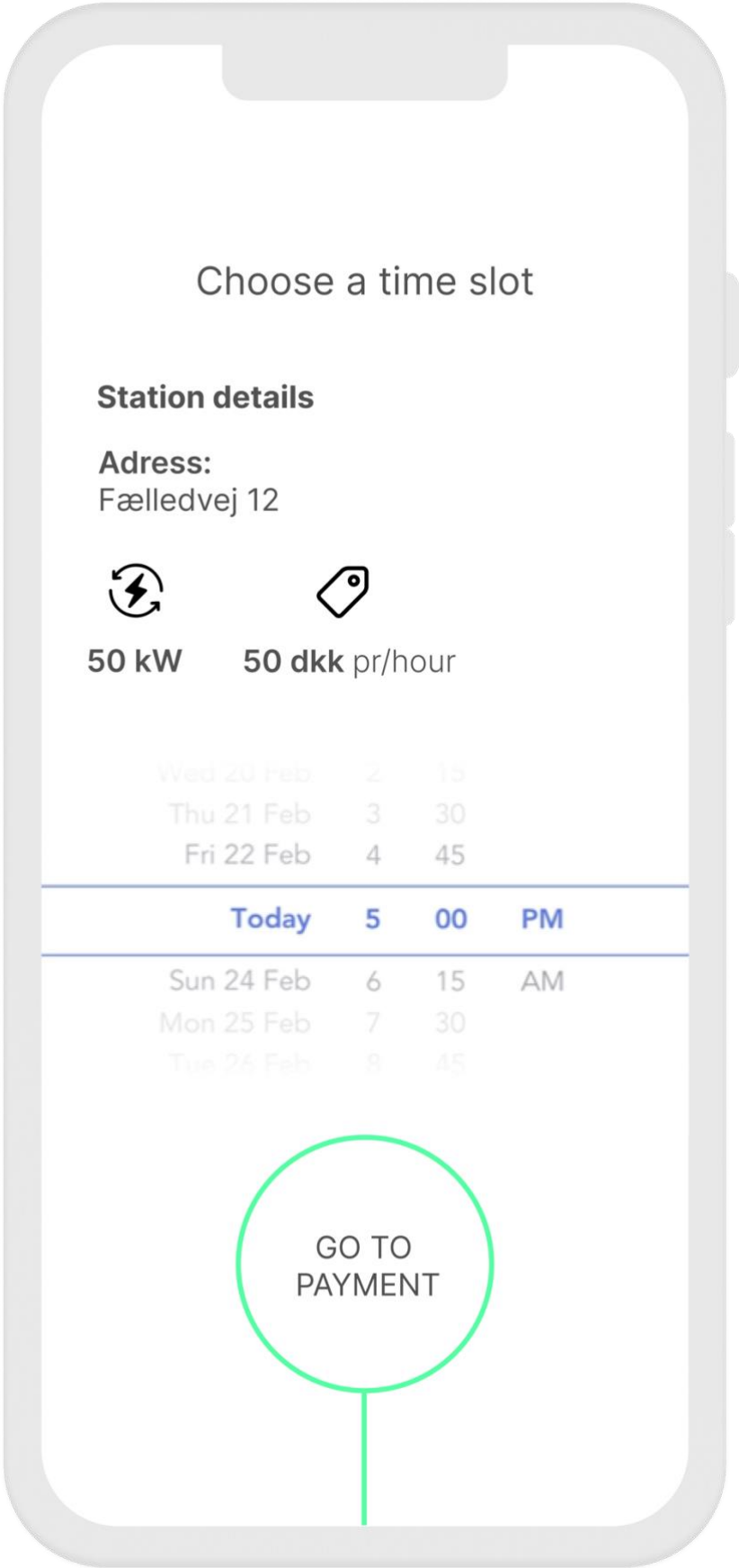


Figure 51—Choosing a charging time slot

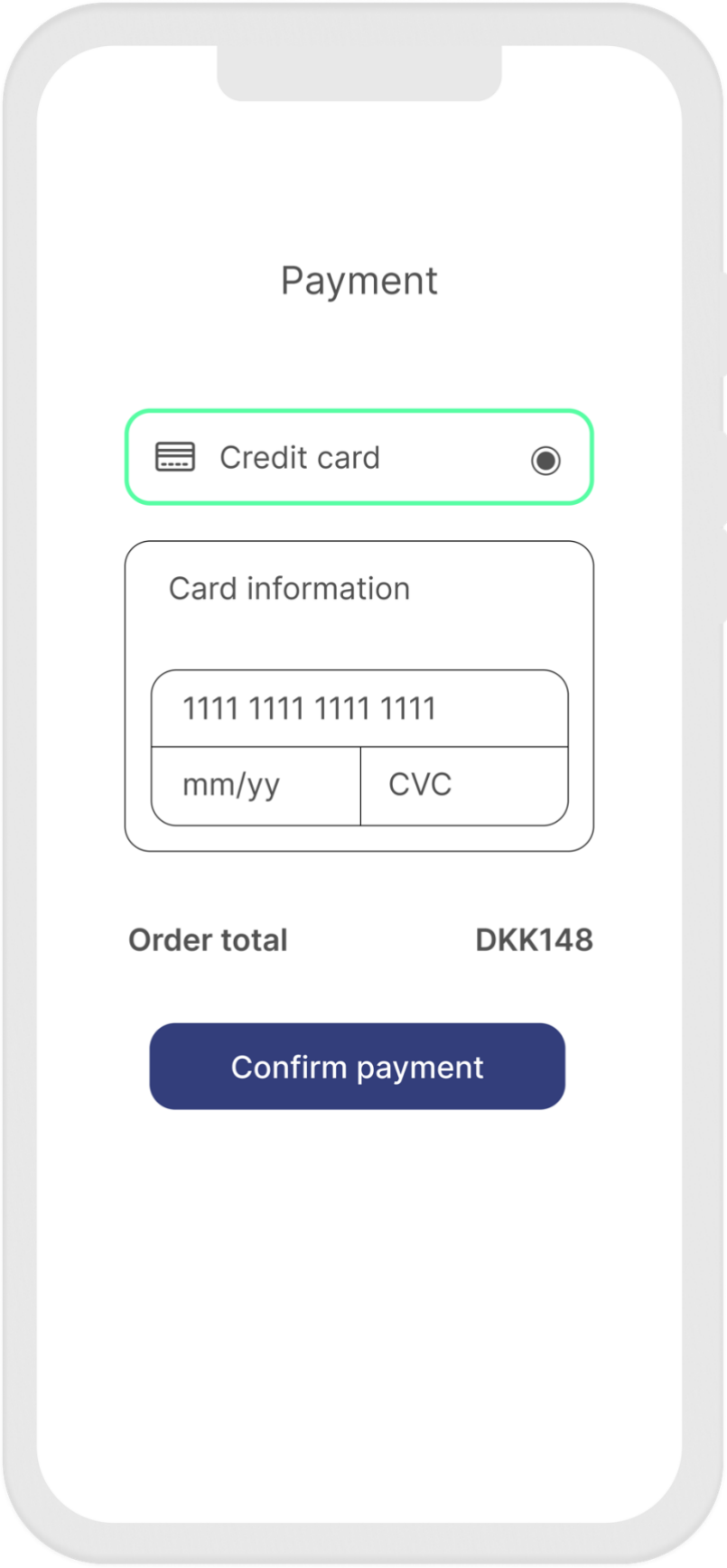


Figure 52—Payment page

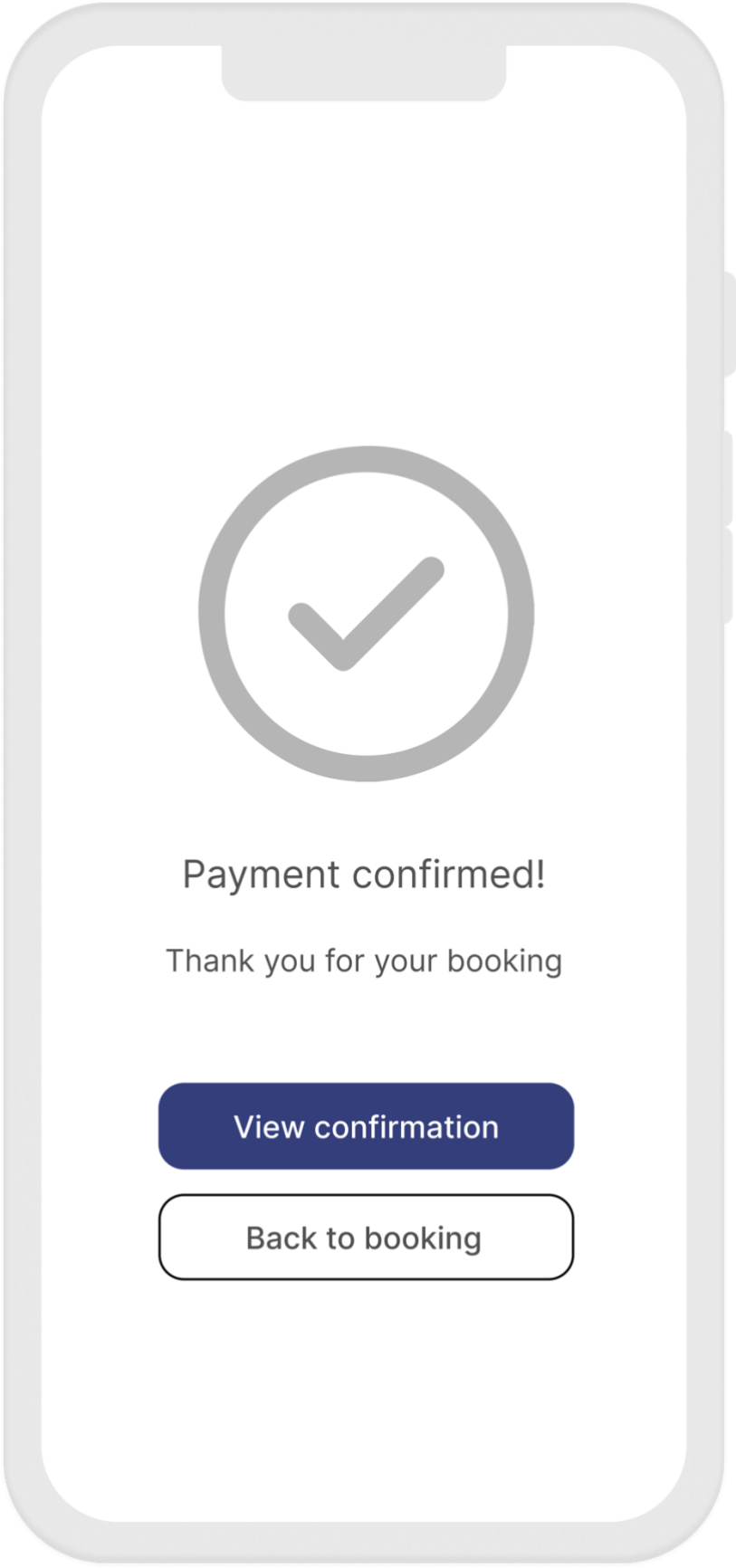


Figure 53—Payment & booking confirmation & option to go back to book more time slots/locations

Summary

- ⇒ When building with Figma, it was important to have the usability of the product/service in mind in order to make it easily understandable for the user.
- ⇒ This mid-fidelity digital prototype aimed to provide more detail and interactivity than the low-fidelity paper wireframes of the proposed reservation app. Here the visuals included elements such as color, fonts and some basic graphics. Each frame was designed with supporting text, buttons and fill out forms in order to show the functionality of the proposed service solution app.
- ⇒ This prototype can be utilized to test with EV users so they can interact with the app's screen elements and functionality, such as with clickable buttons.
- ⇒ Overall, creating this mid-fidelity helped to visualize the app's functionality and will be key in gathering user feedback about how they perceive and experience the app—which is an important step to undertake to ensure this solution is addressing users' challenges and in meeting their needs, in what is the iterative design process thereby reducing the risk of developing a product/service that is not viable.

3.6.7 Usability testing

Having completed the mid-fidelity digital prototype of the reservation service app, the next step is to test it with EV users in order to see how they experience the service solution—and if any adjustments need to be made before continuing to the final design. The purpose of usability testing is to evaluate and gather feedback on the user experience before moving to the final stages of the design development (*Prototype Testing: 6 Steps to Successfully Design, Test, and Implement Your Ideas | Chameleon*, n.d.). Usability tests help to uncover any problems users may encounter, how users navigate through the app to achieve their goal and to observe users behavior—as well as to collect their final feedback (ibid). By ensuring the service solution is properly validated with users, one will avoid implementing a product/service that does not meet the end-users' needs.

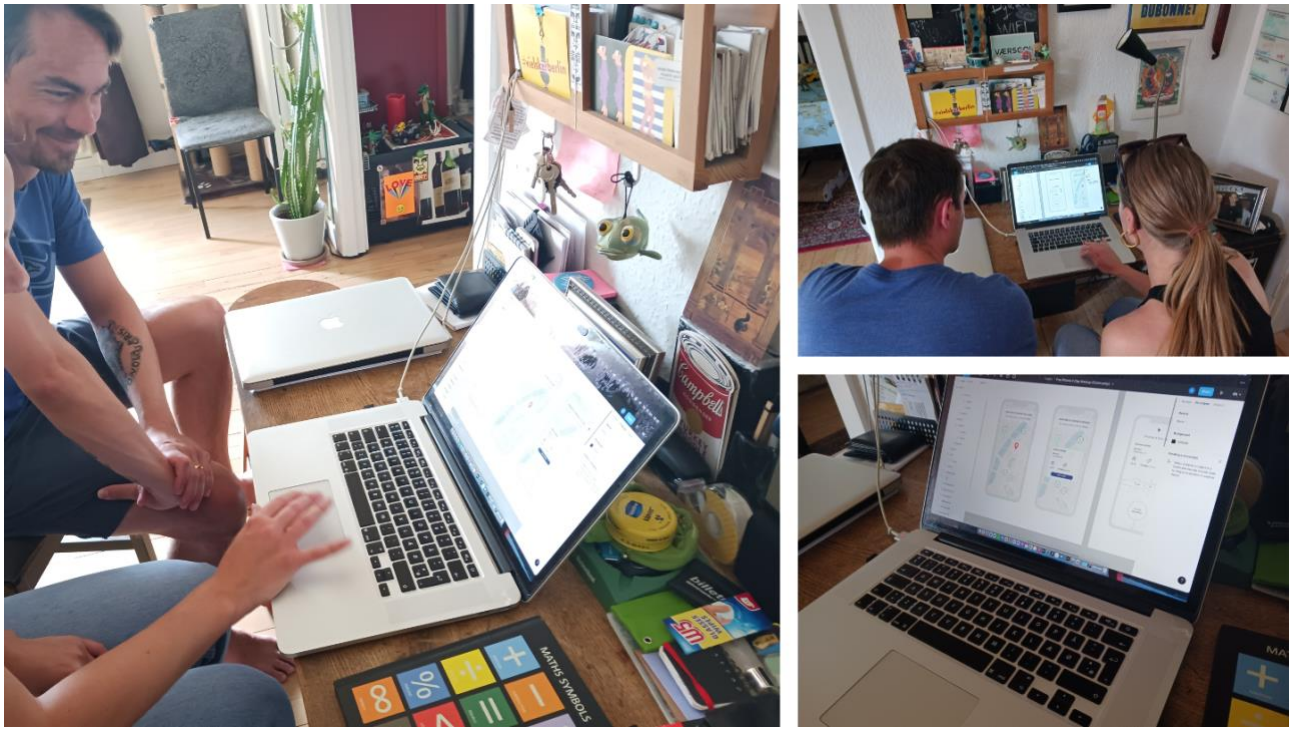


Figure 54—Usability testing with EV driving participants

Testing details

- ⇒ The pilot test included two urban EV users as participants, who were introduced to the service solution and to the pain points it aims to address.
- ⇒ The duration of the pilot test was one hour.
- ⇒ The participants were 30 and 36 years old.
- ⇒ The testing prop was the mid-fidelity digital prototype of the charger reservation app.
- ⇒ The aimed outcome of the test was to see how the two participants understood the service solution, any pain points they experienced while interacting with the prototype, and to collect their final feedback on their overall experience and feedback about the proposed app.

Process

The usability testing began by introducing the scope of the research project, the key insights gained during the research process, and on the resulting ideated service solution they would be testing. The mid-fidelity prototype was presented, with a clear explanation of its limited functionality and on why this was the case—as the prototype aimed to only simulate the app's key interactions. During the testing both users were interacting with the prototype, and one asked how exactly this app would ensure that the charger spot he reserved would not be blocked by a non-charging vehicle, as he constantly experiences this now even though his CPS provider app shows him there is a charger available. This was an aspect of the service app that had not been explained, as it had been taken for granted that the participants would want to know the specific business logic behind the app. Thus, it was then elaborated upon how this app aimed to be a public-private partnership (PPP) between Copenhagen municipality and the private EV company creating this service app—much in the same

way parking service app's collaborate with the municipality. Therefore, the service app provider would bring their business expertise while the municipality would bring their resources and capabilities, such as the ability to ensure non-charging vehicles could not park at chargers without incurring a fine.

Outcome

After the participants tested the mid-fidelity prototype, they were asked how they had experienced the service solution app. Both felt that as a service concept, this was a great solution if done in collaboration with the municipality. And as far as the prototype testing, both expressed that they felt it worked well as it was *"straight forward, user-friendly and with few steps"*, which made it easy to use as often both experience apps that have too many steps to achieve their end goal. This conducted usability testing provided valuable feedback to proceed to the final deliverable.

3.6.8 Conclusion of the develop phase

⇒ The develop phase commenced with the ideation phase, moving from the problem to the solution. HMW' brainstorming session facilitated framing identified EV user problems in a way that encouraged ideation and exploration of different angles and perspectives—and provided ideas to further explore in the ideation activity of Crazy 8's sketching. Combining 'HMW' questions with Crazy 8's sketching in the ideation process encouraged expansive thinking, fostering innovative thinking and the generation of a diverse set of user-centric solutions.

⇒ In order to choose a service solution, three key identified user research pain points were taken into account: blocked or out of service chargers, EV users' staying idly plugged-in after their vehicles are fully charged, and the lack of public CI. The selected service solution, of a reservation app for chargers, was deemed to have the potential to address these key pain points for urban EV users who rely on on-street charging by granting them the ability to reserve chargers when and where they require them. And this service concept was further ideated upon—taking into consideration the literature review findings—for the service app to be created by an EV service provider in collaboration with Copenhagen municipality as a *public-private partnership,* in much the same way the municipality already collaborates with other private companies, such as those with apps offering drivers access to reservation and payment for on-street parking on municipal roads.

⇒ Having applied storyboards helped to visualize the user journey and of the possible interactions with the chosen service solution. The 'big picture' provided an overview of the entire user journey, while the 'close up' storyboard zoomed-in on the service app's functionality, focusing on specific interactions and user tasks. Utilizing both 'big picture' and 'close-up' storyboards, after choosing the service solution, helped to provide a full understanding of the user journey.

⇒ The low-fidelity prototype served as simple representation of the reservation app's layout and functionality—outlining the basic structure of the app's home screen and its functions. Applying it helped to better understand what the user's tasks would be interacting with the app. And the mid-fidelity digital prototype aimed to provide more detail and interactivity to be tested by two EV users.

⇒ Usability testing with the two EV driving participants revealed that they like the concept behind how the service solution would work based on a PPP between the municipality and service provider—and they found the app to be *"straight forward, user-friendly and with few steps"* which made it user-friendly. This conducted usability testing provided valuable feedback for the final deliverable.

3.7 Deliver

The aim of the deliver phase is to summarize the final deliverable of the service design solution addressed in the project report (appendix 4). The entire design process has focused on a user-centric exploration of how service design—at a micro-level of *service as an interaction*—could help to facilitate EV mass adoption in an urban context. The aim has been on identifying opportunities for EV service improvements, and/or innovations, that could help to address users key identified pain points in their transition to e-mobility.

This sub-chapter present the following:

4.4.1 Product report

3.7.1 Product report

The product report aims to communicate the project's context, overview, its key findings about urban EV user challenges and issues with transitioning to e-mobility—and how this has led to the chosen service solution. The product report can be accessed in the below link, and it can also be viewed in appendix 4.

Figure 55—Product report—Self-made via Canva

Product report link:

https://www.canva.com/design/DAFmiC6lzJc/Fh8vpAop5n5mMyZ8kr50dA/edit?utm_content=DAFmiC6lzJc&utm_campaign=designshare&utm_medium=link2&utm_source=sharebutton

4 Discussion

This chapter discusses the academic research questions based on key findings and reflections upon the design process—and the academic and personal learning objectives.

This chapter is divided into the following sub-chapters:

7.1 Reflections on the design process
7.3 Reflections on learning objectives

4.1 Reflections on the design process

The academic research question was focused on examining SDs potential—at a micro-level of *service as an interaction*—to facilitate EVs mass adoption in an urban context, where previous review barriers and opportunities were taken into account and applied to user-centric research in order to identify possibilities for EV service improvements, and/or innovations that could address the key identified urban user pain points in their transition to e-mobility. The basis and motivation for this thesis originated with the initial literature review project undertaken during the 9th semester where it

was revealed that more research is lacking in the area of EV users and in the changes of interaction between users and this new technology.

This thesis was not developed in direct collaboration with a company (public, private or other) thus it did not originate with a design brief, or with a specific problem statement, to commence the design process. Instead, the design process was guided by key findings from the literature review, which sparked curiosities and hunches to further investigate, with a user-centric research focus, on urban EV users. This provided some ambiguity at the start of the process but it also offered freedom of exploration of various ideas and concepts that were mapped out during the initial brainstorm session via a messy brainstorm map. This initial brainstorming led to the commencement of ethnographic field research to observe and communicate with urban EV users, in context, while interacting with EV services. In retrospect, the ethnographic field research was a time-consuming process but it yielded invaluable insights into urban EV users current experiences, motivations, frustrations and wishes for improvements. Furthermore, its findings, inspired seeking out further investigations through the online user research survey (with focus on the qualitative feedback) and with seeking out and conducting semi-structured user interviews. This last two research methods of the discover phase also proved to be time consuming, and challenging in the gathering of survey respondents and interview participants. Nonetheless, the resultant number of participants yielded fantastic insights into urban EV users current experiences and opinions in their transition to e-mobility—and combined with the ethnographic research this felt sufficiently conclusive to continue into the convergent phase of the define phase.

During the define phase, all research insights gathered were analyzed and synthesized—and mapped out with the use of personas, user journey maps and into with clearly defined problem statements. During all the mapping the user perspective was at the center, focused on understanding users' needs, motivations and pain points. Applying tools such as the user journey maps helped to visualize the end-to-end user experience to reaching their end goal—as well as to understanding users emotions and interactions throughout the service journey (Stickdorn & Schneider, 2012). The define phase was instrumental to funneling down to clearly defined user pain points that could be addressed through possible service solutions— which enabled commencing the develop phase of the design process. The challenging part at this stage was in returning to a divergent mode after having been honed in. But in reflection, at this point, it was greatly beneficial that the design thinking process was being followed in conjunction with the Double Diamond framework because it provided a framework to commence with the ideation phase of 'HMW' questions and of Crazy 8's sketching on possible design solutions to the key identified user problem statements. Having combined the 'HMW' questions with Crazy 8's was highly beneficial as is allowed to explore various possibilities in a short amount of time, facilitated by a clearly structured approach and with time-constraints. Furthermore, having an additional participant joining in this ideation phase enabled a variety of different ideas.

In the end, the chosen service solution—a charger reservation app—was considered the solution that was capable of solving three key identified user research pain points: 1) blocked or out of service chargers 2) EV users' staying idly plugged-in after their vehicle is fully charged 3) the current lack

of public CI. The way in which it was ideated that this service solution could address all three pain points was in it being provided by the EV service provider in collaboration with Copenhagen municipality as a *public-private partnership* (PPP). In much the same way the municipality already collaborates/works with other private companies, such as those offering apps for drivers to pay for on-street parking on municipal roads. As the literature review had revealed, PPPs are an effective way to accelerate EV development as they offer a way to access the private sector's resources and professional skills, while easing the burden for municipalities. Here the app service provider would bring their resources and expertise within EV services and infrastructure—while the municipality would bring their own resources and capabilities such as through policy that ensures that chargers are for reserved charging vehicles only. Thus, the three key pain points would be addressed in the following way: 1) Non-plugged vehicles would be prohibited from parking at reservation charge points; 2) EV users' would not be able to stay idly plugged-in after fully charging without incurring a fee charged for every minute they stayed plugged-in after their charging session; and 3) the current lack of public CI would be facilitated by having more of it accessible for EV drivers as now chargers would be based on 2-hour reservation times (and 30-minute for fast chargers)—therefore EV drivers once fully charged will have to unplug, making room for the next EV user to be able to charge. And the municipality would control that chargers are no longer blocked by un-plugged vehicles, which will also increase the availability of available chargers. PPPs enable achieving a 'win-win' situation where the public and private sectors can share both risks and costs and thereby enhance mutual project management and profitability (Hall, 2017; Kneeshaw, 2012). Furthermore, a study by Luo & Qiu (2020) found that a reservation service promotes the development of the EV industry—and their results showed that a reservation charging service implemented in Chengdu, China lowered waiting time for EV users, thereby increasing convenience and providing a positive user service experience to recharging their EVs (Luo & Qiu, 2020).

Following the selection of the chosen service solution, storyboards were sketched to help visualize the user journey and of the possible interactions with the chosen service solution reservation app. Utilizing both 'big picture' and 'close-up' storyboards was highly useful as it helped to provide a full understanding of the user journey with the service solution. Next a user flowchart was mapped out for the reservation app in order to identify the user's step-by-step progression through the reservation service app, of the possible paths the user may take and of the overall structure of the digital experience. The user flowchart helped to provide a high-level overview of the user journey with the reservation app, however user flowcharts only focus on the structure and sequence of steps and not the visual design aspects—so to address this the next step was the creation of low-fidelity wireframe prototypes. The low-fidelity prototype served as simple visual representation of the reservation app's layout and functionality—outlining the basic structure of the app's home screen and its functions. Applying it helped to better understand what the user's tasks would be interacting with the service app. Having the low-fidelity prototype as a representation of the app's functionality and layout, a digital mid-fidelity prototype was developed to allow for a more interactive experience. The mid-fidelity digital prototype aimed to provide more detail and interactivity than the low-fidelity paper wireframes of the app to then be tested with users. Mid-fidelity digital prototypes are well-suited for usability testing to gather feedback from users. Thus, for the final aspect of the develop phase, a

usability testing was undertaken with two participants who interacted with the digital mid-fidelity prototype. Having applied the usability testing helped to validate design decisions for the app and to identify areas of improvement. After the participants tested the mid-fidelity prototype, they were asked how they had experienced the service solution app. Both felt that as a service concept, this was a great solution if done in collaboration with the municipality. And as far as the protype testing, both expressed that they felt it worked well as it was, "straight forward, user-friendly and with few steps" which made it easy to use. This conducted usability testing provided valuable feedback to proceed to the final deliverable.

4.2 Reflections on learning objectives

4.2.1 Official learning objectives

This thesis allowed to independently practice user-centric service design approaches and methods, thus helping to fortify the service design skills and competences learned during the duration of this Master's program. The context addressed of facilitating EVs mass adoption, with urban dwellers without at-home charging accessibility, proved to be a complex case to analyze but one that could be zoomed-in on to adequately address EV users' problems and opportunities—thereby allowing to showcase the application of service design capabilities at the micro-level of *service as an interaction* and further complimented by user-experience (UX) design methods and approaches. During the design process, the analysis and synthesis of the gathered user-centric research demonstrated the ability to find a clearly defined service [design] solution. What is more, the thesis permitted the possibility to independently upskill professional development and specialization by undertaking a Google UX Design Certificate course which was also applied to the development of the thesis.

4.2.2 Personal learning objectives

A key goal for the thesis was to gain more theoretical knowledge and practical experience of zooming-in and working with *service as an interaction* with focus on the user experience (UX)—and this was truly achieved throughout the duration of the thesis process. Secondly, and quite importantly, to practice self-care and mindfulness—staying open, curious and to enjoy the thesis process in its exploration, learning and application of different service design tools and methods. The entire process was extremely exciting, interesting and fulfilling though at the end, due to nerves occasionally overwhelming. But overall an incredible learning experience. In regards to hopefully finding a feasible service solution that can address current user pain points in transitioning to e-mobility, I sincerely feel like it could be something that could be pitched to Copenhagen municipality if created as suggested, to be as a public-private partnership. Lastly, the hope is that this research will inspire further EV user research, and on how charging services should be provided to ensure a mass transition to e-mobility to help reach our CO2 reduction goals.

5 Conclusion

This chapter summarizes the key findings related to the academic research question. Additionally, it presents the limitations of this study and possible areas of future research.

The chapter is divided into the following subchapters:

5.1 Key findings related to the research question
5.2 Limitations and possible areas of future research

5.1 Key findings related to the research question

In this thesis, the research question explored how service design, at the micro-level of *service as an interaction*, could zoom into the user experience of being an urban EV driver, and to emphatically investigate what this experience is like (i.e., what is working and what could be improved upon) in order to facilitate a smoother transition to EV mass adoption in an urban context—with focus on urban dwellers without private at-home charging accessibility.

To structure the design process, the Double Diamond framework was used in conjunction with the design thinking process to be incorporated into the service design approaches and methods. These activities included user-centered research, analysis and synthesis, ideation and ending with a chosen service solution that was tested with users for the service concept's validation.

In the end, the chosen service solution—a charger reservation app—was considered the solution that was capable of solving three key identified user research pain points: 1) blocked or out of service chargers 2) EV users' staying idly plugged-in after their vehicle is fully charged 3) the current lack of public CI. This service solution could address all three pain points by it being developed by the EV app service provider in collaboration with Copenhagen municipality as a *public-private partnership* (PPP). As the literature review had revealed, PPPs are an effective way to accelerate EV development as they offer a way to access the private sector's resources and professional skills, while easing the burden for municipalities. Here the app service provider would bring their resources and expertise within EV services and infrastructure, such as with the maintenance of out of order chargers—while the municipality would bring their own resources and capabilities such as through policy that ensures that chargers are for reserved charging vehicles only.

In answering the research question, zooming in at the micro-level of *service as an interaction*, service design capabilities were applied with: a) a user-centric perspective at the center of the design solution based on a deep understanding of urban EV users' needs, motivations and pain points—and here empathy was a key capability as it required the capacity to understand user feelings, thoughts and individual experiences; b) applying tools such as personas, journey maps, storyboards, and user flow charts helped to visualize the end-to-end user experience, to identify touchpoints and to better understand user emotions and interactions throughout the entire user service journey; c) lastly, the

tangible application of low-and mid-fidelity prototypes facilitated making the service solution tangible to be tested with users for the final validation of the service solution concept. Service design's potential at a micro-level has the ability to influence something as complex as the e-mobility transition by applying user-centric and empathic design that helps to lessen the complexity and focuses on zooming-in on the interaction between the user and this new emergent technology and of its service offerings. SD at this level enables keeping the user at center to design a product/service that is truly solving the user's problem and/or addressing the user's needs— in this case helping to address EV users the transition to e-mobility, and with focus on urban dwellers who depend on accessible and reliable on-street charging services for their charging needs.

5.2 Limitations and future research

The following subchapter will outline the limitations of the design process based on the academic research question. Thereafter, future research possibilities based on these thesis results will be explored.

First and foremost, the research in this thesis was not developed in direct collaboration with a company (public, private or other) thus it did not originate with a design brief, or with a specific problem statement, to commence the design process. Instead, the design process was guided by key findings from the conducted literature review. Thus it is difficult to say if the insights gathered and of the resulting PPP service solution would be found feasible to both a private EV service provider and to Copenhagen municipality.

Secondly, the data gathered during the design process is a small population sampling, both in survey and interview participants, and only represents a tiny percentage of current urban EV users. So the gathered data cannot be deemed conclusive in regards to all urban dwellers and to the key pain points they experience in their transition to e-mobility. Furthermore, the timeframe of the design process research was cross-sectional (i.e., 5-months)—and this timeframe is considered to be quite short in what is an emergent industry, with changes happening constantly, revealed by the year-on-year growing number of academic studies.

Thirdly, the development of urban EV mass adoption is context specific from city to city and country to country—what may work, for example, in Copenhagen may not work in other metropolitan cities, and vice versa.

Lastly, it is important to highlight the personal bias in the conducted design process based on personal interpretations. However it should be noted that per Saunders (2016) in design research the nature of the research is exploratory, and therefore research interpretations are value-bound because service design researchers form part of what is being researched, and subjective interpretations are key contributors to the final service solution (Saunders, 2016).

With regard to future research, there are limited studies that examine service design facilitating EVs mass adoption, in an urban context (or otherwise)—as was touched upon in the literature review. Future research could address focusing on other cities outside of Denmark. Furthermore, future studies within Denmark could focus research on a national level such as with focus on the countryside in regards to charging infrastructure services—as it was found that currently many EV users are hesitant to transition to a full EV without the assurance they can charge their vehicles when driving outside of the city to other parts of country. Future research could also focus on the transition of e-mobility beyond that of private consumers and taking into account, for example, professional car fleets (such as taxis or car sharing services) and industry sectors such as maritime, aviation, agriculture, logistics, etc.

Lastly, more research at a systems level has the potential to greatly contribute to e-mobility's mass adoption, zooming out a macro-level of *service as a systemic institution* (Morelli, et al., 2021)—with special focus on service design for policy as this emergent industry is complex and is deemed a wicked problem that requires looking at the entire EV ecosystem, and to collaborating with a diverse set of stakeholders that includes policymakers, experts in the field, utilities companies, service providers, knowledge institutions and especially with EV users (current and potential). Here it is important to note that continuous user research is needed, as EV adoption increases—while at the same time there remains much uncertainly on how EV services ought to be designed and delivered (LaMonaca & Ryan, 2022).

6 References

Adhikari, M., Ghimire, L. P., Kim, Y., Aryal, P., & Khadka, S. B. (2020). Identification and analysis of barriers against electric vehicle use. *Sustainability (Switzerland)*, *12*(12), 1–20. https://doi.org/10.3390/SU12124850

Advantages of Mind Mapping | StudySmarter. (n.d.). Retrieved June 9, 2023, from https://www.studysmarter.co.uk/magazine/advantages-of-mind-mapping/

Anderson, T. (2019). Electric vehicles in Danish Municipalities: An Understanding of Motivations, Barriers, and the Future of Sustainable Mobility. *Vehicles*, *1*(1), 57–68. https://doi.org/10.3390/vehicles1010004

Anthopoulos, L., & Kolovou, P. (2021). A multi-criteria decision process for ev charging stations' deployment: Findings from greece. *Energies*, *14*(17), 1–16. https://doi.org/10.3390/en14175441

Bakker, S., & Jacob Trip, J. (2013). Policy options to support the adoption of electric vehicles in the urban environment. *Transportation Research Part D: Transport and Environment*, *25*, 18–23. https://doi.org/10.1016/j.trd.2013.07.005

Bakker, S., Maat, K., & van Wee, B. (2014). Stakeholders interests, expectations, and strategies regarding the development and implementation of electric vehicles: The case of the Netherlands. *Transportation Research Part A: Policy and Practice*, *66*(1), 52–64. https://doi.org/10.1016/j.tra.2014.04.018

Banjarey, R., Jacob, I., Yadav, S., Yamujala, S., Agrawal, A. K., & Bhakar, R. (2021). Electric Vehicle Charging Policies in Indian states: Key Learnings from International Experiences. *ICPS 2021 - 9th IEEE International Conference on Power Systems: Developments towards Inclusive Growth for Sustainable and Resilient Grid*. https://doi.org/10.1109/ICPS52420.2021.9670261

Berkeley, N., Bailey, D., Jones, A., & Jarvis, D. (2017). Assessing the transition towards Battery Electric Vehicles: A Multi-Level Perspective on drivers of, and barriers to, take up. *Transportation Research Part A: Policy and Practice*, *106*(June 2016), 320–332. https://doi.org/10.1016/j.tra.2017.10.004

Best practices for Crazy Eights | Coursera. (n.d.). Retrieved June 13, 2023, from https://www.coursera.org/learn/start-ux-design-process/supplement/Jmoa1/best-practices-for-crazy-eights

Boucetta, M., Hossain, N. U. I., Jaradat, R., Keating, C., Tazzit, S., & Nagahi, M. (2021). The architecture design of electrical vehicle infrastructure using viable system model approach. *Systems*, *9*(1). https://doi.org/10.3390/systems9010019

Broadbent, G. H., Drozdzewski, D., & Metternicht, G. (2018). Electric vehicle adoption: An analysis of best practice and pitfalls for policy making from experiences of Europe and the US. *Geography Compass*, *12*(2), 1–15. https://doi.org/10.1111/gec3.12358

Build an empathy map | Coursera. (n.d.-a). Retrieved June 2, 2023, from https://www.coursera.org/learn/start-ux-design-process/supplement/c6GCS/build-an-empathy-map

Build an empathy map | Coursera. (n.d.-b). Retrieved June 13, 2023, from https://www.coursera.org/learn/start-ux-design-process/supplement/c6GCS/build-an-empathy-map

Burkert, A., Fechtner, H., & Schmuelling, B. (2021). Interdisciplinary analysis of social acceptance regarding electric vehicles with a focus on charging infrastructure and driving range in Germany. *World Electric Vehicle Journal*, *12*(1), 1–33. https://doi.org/10.3390/wevj12010025

Calearo, L. ;, Sevdari, K. ;, & Marinelli, M. (2021). *Status e-mobility DK*.

Chavez, G. E. (2021). *Title: Relevance of Foresight to Service Systems Design*.

Chavez, G. E. (2022). *A literature review on how SDD could potentially contribute to electric vehicle mass adoption in an urban context*.

Define hypothesis statements | Coursera. (n.d.). Retrieved June 13, 2023, from https://www.coursera.org/learn/start-ux-design-process/supplement/h0z9K/define-hypothesis-statements

Define problem statements | Coursera. (n.d.). Retrieved June 13, 2023, from https://www.coursera.org/learn/start-ux-design-process/supplement/DDRka/define-problem-statements

Determine a value proposition | Coursera. (n.d.). Retrieved June 13, 2023, from https://www.coursera.org/learn/start-ux-design-process/supplement/FNFGw/determine-a-value-proposition

Egnér, F., & Trosvik, L. (2018). Electric vehicle adoption in Sweden and the impact of local policy instruments. *Energy Policy*, *121*, 584–596. https://doi.org/10.1016/j.enpol.2018.06.040

Elkind, E. (2017). *UC Berkeley Center for Law, Energy & the Environment Title Plugging Away: How to Boost Electric Vehicle Charging Infrastructure*. https://escholarship.org/uc/item/7mf3p66c

Empathy Mapping: The First Step in Design Thinking. (n.d.). Retrieved June 13, 2023, from https://www.nngroup.com/articles/empathy-mapping/

ETHNOGRAPHY FIELDGUIDE. (n.d.).

Everything You Need to Know About Mid Fidelity Prototype. (n.d.). Retrieved June 16, 2023, from https://mockitt.wondershare.com/prototyping/mid-fidelity-prototype.html

Falchetta, G., & Noussan, M. (2021). Electric vehicle charging network in Europe: An accessibility and deployment trends analysis. *Transportation Research Part D: Transport and Environment*, *94*(April), 102813. https://doi.org/10.1016/j.trd.2021.102813

Fitzsimmons, J. F. M. B. S. (2014). *Service Management: Operations, Strategy, Information Technology* (8th ed.). McGraw Hill Education.

Fleischmann, K. (2020). *Designers as change agents in the Circular Economy*. https://www.ellenmacarthurfoundation.org/

Haddadian, G., Khodayar, M., & Shahidehpour, M. (2015). Accelerating the Global Adoption of Electric Vehicles: Barriers and Drivers. *Electricity Journal*, *28*(10), 53–68. https://doi.org/10.1016/j.tej.2015.11.011

Hall, D. (2017). *EMERGING BEST PRACTICES FOR ELECTRIC VEHICLE CHARGING INFRASTRUCTURE Dale Hall, Nic Lutsey*. www.theicct.org

Hall, S., Shepherd, S., & Wadud, Z. (2016). *The Innovation Interface Business model innovation for electric vehicle futures. In collaboration with Future Cities Catapult*. 1–68. http://homepages.see.leeds.ac.uk/~earshal/Files/11167_SEE_electrical_vehicles_report_WEB.pdf

He, S. Y., Kuo, Y. H., & Sun, K. K. (2022). The spatial planning of public electric vehicle charging infrastructure in a high-density city using a contextualised location-allocation model. *Transportation Research Part A: Policy and Practice*, *160*(April), 21–44. https://doi.org/10.1016/j.tra.2022.02.012

History of the Double Diamond - Design Council. (n.d.). Retrieved June 9, 2023, from https://www.designcouncil.org.uk/our-resources/the-double-diamond/history-of-the-double-diamond/

How to apply a design thinking, HCD, UX or any creative process from scratch — Revised & New Version | by Dan Nessler | UX Collective. (n.d.). Retrieved June 9, 2023, from https://uxdesign.cc/how-to-solve-problems-applying-a-uxdesign-designthinking-hcd-or-any-design-process-from-scratch-v2-aa16e2dd550b

Introduction to wireframes | Coursera. (n.d.). Retrieved June 14, 2023, from https://www.coursera.org/learn/wireframes-low-fidelity-prototypes/lecture/Rm1j6/introduction-to-wireframes

Journey Mapping 101. (n.d.). Retrieved June 13, 2023, from https://www.nngroup.com/articles/journey-mapping-101/

Kimbell, L. (2009). *INSIGHTS FROM SERVICE DESIGN PRACTICE*.

Kneeshaw, S. (2012). *EVS26 International Battery, Hybrid and Fuel Cell Electric Vehicle Symposium European knowledge transfer network on urban Electric Vehicle strategies*. www.urbact.eu/evue.

Köksal, E. (2021). "Electric Vehicle Ecosystem in Turkey: Emerging Issues and Future Outlook" The economics of electric vehicles and the need for a public policy. In *Network Industries Quarterly Turkey* | (Vol. 1). https://ssrn.com/abstract=3869739

Kongklaew, C., Phoungthong, K., Prabpayak, C., Chowdhury, M. S., Khan, I., Yuangyai, N., Yuangyai, C., & Techato, K. (2021). Barriers to electric vehicle adoption in Thailand. *Sustainability (Switzerland)*, *13*(22), 1–13. https://doi.org/10.3390/su132212839

LaMonaca, S., & Ryan, L. (2022). The state of play in electric vehicle charging services – A review of infrastructure provision, players, and policies. *Renewable and Sustainable Energy Reviews*, *154*(September 2021), 111733. https://doi.org/10.1016/j.rser.2021.111733

Learn more about creating storyboards | Coursera. (n.d.). Retrieved June 14, 2023, from https://www.coursera.org/learn/wireframes-low-fidelity-prototypes/supplement/eNAq1/learn-more-about-creating-storyboards

Learn more about design ideation | Coursera. (n.d.-a). Retrieved June 13, 2023, from https://www.coursera.org/learn/start-ux-design-process/supplement/NEUOp/learn-more-about-design-ideation

Learn more about design ideation | Coursera. (n.d.-b). Retrieved June 13, 2023, from https://www.coursera.org/learn/start-ux-design-process/supplement/NEUOp/learn-more-about-design-ideation

Learn more about goal statements | Coursera. (n.d.). Retrieved June 13, 2023, from https://www.coursera.org/learn/wireframes-low-fidelity-prototypes/supplement/WNvgz/learn-more-about-goal-statements

Learn more about personas | Coursera. (n.d.). Retrieved June 13, 2023, from https://www.coursera.org/learn/start-ux-design-process/supplement/WMeZK/learn-more-about-personas

Learn more about user stories | Coursera. (n.d.). Retrieved June 13, 2023, from https://www.coursera.org/learn/start-ux-design-process/supplement/97qJ5/learn-more-about-user-stories

Luo, X., & Qiu, R. (2020). Electric vehicle charging station location towards sustainable cities. *International Journal of Environmental Research and Public Health*, *17*(8). https://doi.org/10.3390/ijerph17082785

Maia, S. C., Teicher, H., & Meyboom, A. L. (2015). Infrastructure as social catalyst: Electric vehicle station planning and deployment. *Technological Forecasting and Social Change*, *100*, 53–65. https://doi.org/10.1016/j.techfore.2015.09.020

Manzini, E. (2015). *Design, When Everybody Designs: An Introduction to Design for Social Innovation*. MIT Press.

Morelli, N., de Götzen, A., & Simeone, L. (2021). *Service Design Capabilities* (Vol. 10). Springer Nature. https://doi.org/10.1007/978-3-030-56282-3

Nyhedsoverblik 1. juni - TV 2. (n.d.). Retrieved June 9, 2023, from https://nyheder.tv2.dk/2023-06-01-nyhedsoverblik-1-juni#entry=3889162

Pardo-Bosch, F., Pujadas, P., Morton, C., & Cervera, C. (2021). Sustainable deployment of an electric vehicle public charging infrastructure network from a city business model perspective. *Sustainable Cities and Society*, *71*. https://doi.org/10.1016/j.scs.2021.102957

Penin, L. (2019). *Design the Invisible*. Bloomsbury Visual Arts.

Peruccon, A. (2021). *Planning more clear and inclusive futures by integrating Service Design within a Future Studies and Foresight process: A case study to future-proof urban cooperative housing development in Copenhagen*.

Prototype Testing: 6 Steps to Successfully Design, Test, and Implement Your Ideas | Chameleon. (n.d.). Retrieved June 16, 2023, from https://www.chameleon.io/blog/prototype-testing

Rezvani, Z., Jansson, J., & Bodin, J. (2015). Advances in consumer electric vehicle adoption research: A review and research agenda. *Transportation Research Part D: Transport and Environment*, *34*, 122–136.

Salah, K., & Kama, N. (2017). Inter-service provider charging protocol: A solution to address range anxiety of electric vehicle owners. *Energy Procedia*, *136*, 157–162. https://doi.org/10.1016/j.egypro.2017.10.313

Santos, G., & Davies, H. (2020). Incentives for quick penetration of electric vehicles in five European countries: Perceptions from experts and stakeholders. *Transportation Research Part A: Policy and Practice*, *137*, 326–342. https://doi.org/10.1016/j.tra.2018.10.034

Saunders, M. L. P. T. A. (2016). *Research Methods for Business Students* (7th ed.). Pearson.

Shen, Z. J. M., Feng, B., Mao, C., & Ran, L. (2019). Optimization models for electric vehicle service operations: A literature review. *Transportation Research Part B: Methodological*, *128*, 462–477. https://doi.org/10.1016/J.TRB.2019.08.006

Shi, L., Hao, Y., Lv, S., Cipcigan, L., & Liang, J. (2021). A comprehensive charging network planning scheme for promoting EV charging infrastructure considering the Chicken-Eggs dilemma. *Research in Transportation Economics*, *88*. https://doi.org/10.1016/j.retrec.2020.100837

Sierzchula, W., Bakker, S., Maat, K., & Van Wee, B. (2014). The influence of financial incentives and other socio-economic factors on electric vehicle adoption. *Energy Policy*, *68*, 183–194. https://doi.org/10.1016/j.enpol.2014.01.043

Silvester, S., Beella, S. K., Van Timmeren, A., Bauer, P., Quist, J., & Van Dijk, S. (2013). Exploring design scenarios for large-scale implementation of electric vehicles; The Amsterdam Airport Schiphol case. *Journal of Cleaner Production*, *48*, 211–219. https://doi.org/10.1016/j.jclepro.2012.07.053

Statistics Denmark. (n.d.). Retrieved February 28, 2023, from https://www.dst.dk/en/Statistik/emner/borgere/boligforhold

Stickdorn & Schneider. (2012). *This Is Service Design Doing*. O'Reilly Media.

Stickdorn & Schneider. (2018). This Is Service Design Doing: Applying Service Design Thinking in the Real World. In *Stickdorn, Mark; Hormess, Markus Edgar; Lawrence, Adam; Schneider, Jakob*.

The Climate Council. (n.d.). Retrieved February 28, 2023, from https://klimaraadet.dk/da/nyhed/klimaraadet-store-risici-paa-regeringens-vej-mod-2030-maalet

The Climate Council warns in a new report: There is too high a risk that the government will not achieve Denmark's goals - TV 2. (n.d.). Retrieved March 1, 2023, from https://nyheder.tv2.dk/politik/2023-02-28-klimaraadet-advarer-i-ny-rapport-der-er-for-hoej-risiko-for-at-regeringen-ikke

The Economist. (2022). Daily Espresso. *The Economist*.

The Hague - Request charging point for electric car. (n.d.). Retrieved June 13, 2023, from https://www.denhaag.nl/en/parking/apply-for-parking-space-or-charging-point/request-charging-point-for-electric-car.htm

The International. (n.d.). Retrieved February 28, 2023, from https://www.the-intl.com/post/denmark-s-electric-vehicle-charge-points

The Post. (n.d.). Retrieved February 28, 2023, from https://cphpost.dk/2023-01-12/news/denmarks-electric-car-fleet-increased-considerably-in-2022/

Trip, J., Lima, J., & Bakker, S. (2019). Electric mobility policies in the North Sea Region countries. In *Delft University of Technology* (Issue 35). http://e-mobility-nsr.eu/fileadmin/user_upload/NEWS/Electric_mobility_policies_in_the_North_Sea_Region_countries/3.3_-_E-mobility_policies_in_the_NSR_countries.pdf

User Research in UX Design: The Complete Beginner's Guide. (n.d.). Retrieved May 18, 2023, from https://careerfoundry.com/en/blog/ux-design/the-importance-of-user-research-and-how-to-do-it/

User Stories: As a [UX Designer] I want to [embrace Agile] so that [I can make my projects user-centered] | IxDF. (n.d.). Retrieved June 13, 2023, from https://www.interaction-design.org/literature/article/user-stories-as-a-ux-designer-i-want-to-embrace-agile-so-that-i-can-make-my-projects-user-centered

van der Kam, M., van Sark, W., & Alkemade, F. (2020). Multiple roads ahead: How charging behavior can guide charging infrastructure roll-out policy. *Transportation Research Part D: Transport and Environment*, *85*(July), 102452. https://doi.org/10.1016/j.trd.2020.102452

Van der Steen, M., Van Schelven, R. M., Van Deventer, P., Van Twist, M., & Kotter, R. (2015). Policy strategies for an emergent technology: lessons from the analysis of EV-policy in 8 North- European countries. In *World Electric Vehicle Journal* (Vol. 7, Issue 4, pp. 710–721). https://doi.org/10.3390/wevj7040710

Vink, J., Tronvoll, B., Edvardsson, B., & Wetter-Edman, K. (2017). *Service Ecosystem Design: Doing Institutional Work through Design Service Design for Innovation View project Drivers of customers' service experiences View project*. https://www.researchgate.net/publication/317901747

What Is an Empathy Map? [Complete Guide]. (n.d.). Retrieved June 13, 2023, from https://careerfoundry.com/en/blog/ux-design/what-is-an-empathy-map/#a-note-on-the-limitations-of-empathy-mapping

What Is Ideation? 2023 Guide To The Design Thinking Phase. (n.d.). Retrieved June 13, 2023, from https://careerfoundry.com/en/blog/ux-design/what-is-ideation-in-design-thinking/

Why Personas Fail. (n.d.). Retrieved June 13, 2023, from https://www.nngroup.com/articles/why-personas-fail/

Wicki, M., Brückmann, G., & Bernauer, T. (2022). How to accelerate the uptake of electric cars? Insights from a choice experiment. *Journal of Cleaner Production*, *355*(March), 131774. https://doi.org/10.1016/j.jclepro.2022.131774

Wilson, A. Z. V. B. M. J. G. D. (2016). *Services Marketing: Integrating Customer Focus Across the Firm* (3rd ed.). McGraw Hill Education.

Wireflows: A UX Deliverable for Workflows and Apps. (n.d.-a). Retrieved June 14, 2023, from https://www.nngroup.com/articles/wireflows/

Wireflows: A UX Deliverable for Workflows and Apps. (n.d.-b). Retrieved June 14, 2023, from https://www.nngroup.com/articles/wireflows/

Wolbertus, R., Kroesen, M., van den Hoed, R., & Chorus, C. G. (2018). Policy effects on charging behaviour of electric vehicle owners and on purchase intentions of prospective owners: Natural

and stated choice experiments. *Transportation Research Part D: Transport and Environment*, *62*, 283–297. https://doi.org/10.1016/j.trd.2018.03.012

Yang, T., Long, R., Li, W., & Rehman, S. U. R. (2016). Innovative application of the public-private partnership model to the electric vehicle charging infrastructure in China. *Sustainability (Switzerland)*, *8*(8). https://doi.org/10.3390/su8080738

7 Appendix

Appendix 1—Field research

https://drive.google.com/drive/folders/1AAHEpyQeNBk-f1MsTdjVd8o-99EJRLDH?usp=sharing

Appendix 2—Online survey

https://docs.google.com/forms/d/1Ctd3-pbvu9fyMRksi6EvothmrlpDEylbdNpmij7zIcQ/prefill

Appendix 3—Email with CPS provider CLEVER

Dear Customer Service Team,

I have been a customer of yours since 2022.

I am a customer that relies solely on your on-street charging stations as I reside in an apartment complex where I am unable to have private charging installed.

I am writing you to inquire about a scenario I frequently encounter, which is that of blocked charging points by petrol vehicles, or even hybrid vehicles, that are parking but not charging. Hence blocking accessibility to my being able to charge my vehicle.

This is a very frustrating scenario, as the App indicates that there is are charging spot(s) available to then arrive and find that this is not the case. In addition, I never find these vehicles with parking tickets from the municipality citing these vehicles for occupying these charging spots.

In fact, most recently I encountered six Clever charge spots that were blocked (below images) at the Hødevej Charging station in Amager. And none of these vehicles had parking tickets. Instead, only some of the vehicles had flyers on their windshield from fDEL//E.On.

This is a deeply frustrating experience, and I am curious to know if there is anything that is being, or has been, done to resolve this issue.

Kindly awaiting your reply.

Best regards,
Elisa Chavez

SV: RE: public charging station accessibility SID:055100000908 Inbox ×

Clever Kundeservice <kundeservice@clever.dk> Tue, Mar 28, 11:00 AM
to me

Hi Elisa,

Thank you for reaching out with your inquiry.

We are aware of the issue, and we are also deeply sorry we aren't able to find a right solution. The case is we don't own the parking lots where all our charging points are. Therefore we do not have any permission to make any rules about parking the specific places.

We will always appeal to everyone with a good charging culture, but it's almost impossible with the fossil cars.

I will refer you to contact the company that owns the parking lot. I know a few places, there are rules, that you can't park at a charging point without charging etc.

But unfortunately we are not able to fix this issue by our own.

If you got further questions, do not hestitate to contact us again.

Best regards
Silas
Customer Service
+45 82 30 30 30
kundeservice@clever.dk

Vi sidder ved telefonerne i tidsrummene:

Mandag: Kl. 08:30-15:30
Tirsdag: Kl. 08:30-15:30
Onsdag: Kl. 09:30-15:30
Torsdag: Kl. 08:30-15:30
Fredag: Kl. 08:30-14:30

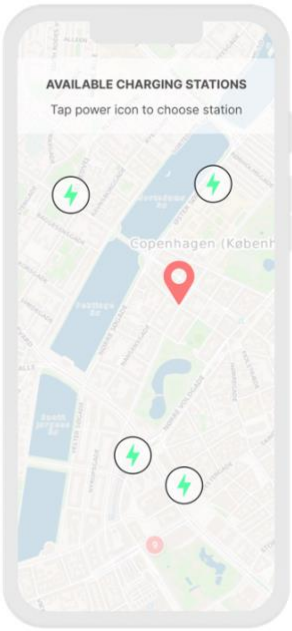
Appendix 4—Product report

Table of contents

Project Context

- Years ago DK understood that roads need to become greener in order to meet CO2 reduction ambitions by 2025 and 2030 but currently the CO2 reduction numbers are not being met as expected
- E-mobility is a central solution but this requires increasing charging infrastructure of its services, especially for urban dwellers relying solely on on-street charging
- Currently 46% of Copenhageners live in multi-unit dwellings & currently there is a growing gap in the number of chargers available to fulfill urban dwellers charging needs
- Charging services are fragmented and lacking, while the number of EVs on the road has increased three fold
- This opposing trend between supply and demand can slow down EVs mass adoption, especially the case for urban dwellers who have been found to be two and half times less likely to transition to an EV as those with at-home private charging accessability
- Large EV penetration necessitates CI, and of its services, to satisfy all market needs

Project overview



The product:

This EV service app will allow urban EV users, who rely on on-street charging, to reserve chargers when and where they need them

Project duration:

October 2022 to June 2023

Project overview

The problem:

Currently urban EV users deal with three main pain points in their transition to e-mobility:

- Blocked, or out of service, chargers
- Other EV users staying idly plugged-in
- Lack of public charging infrastructure

The goal:

For urban EV users, relying on on-street charging, to be able to reserve chargers when and where they need them

Overview of the design process

Academic research question

How can service design, at a micro-level, help to facilitate the transition to electric vehicles (EVs) mass adoption in an urban context?

User research: summary

Various service design research methods were applied in order to understand urban EV users current experiences in their transition to e-mobility: desk research, ethnographic field research, online mixed method survey and semi-structured interviews with urban EV users who rely on on-street charging services.

Initial assumptions, prior to commencing the user research, were confirmed with regards to EV users frequently experiencing non-plugged vehicles blocking chargers, of other EV users staying idly plugged-in even after their cars are fully charged and of lacking public charging infrastructure.

Key findings

1

Blocked chargers by unplugged cars

This is currently one of the most frequently experienced pain point for urban EV users. And CPH municipality has not made it fineable thus CPS providers cannot do anything.

2

EV driver's staying idly plugged-in

At CS' without parking times, or in the evenings, EV drivers often stay plugged-in after their vehicles are fully charged– taking away the possibility for others to have accessibility to charge.

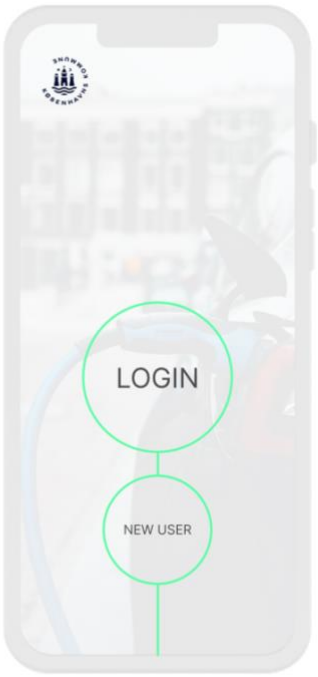
3

Lack of on-street charging stations

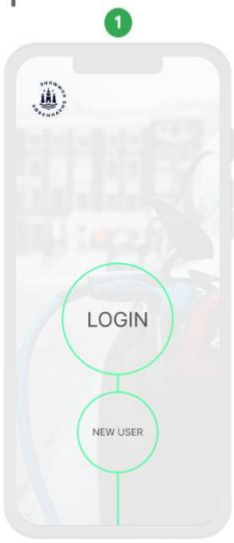
There is a growing gap in the number of chargers available in CPH as the number of EVs on the road are 3 times as many but CI development is lagging behind.

The service concept

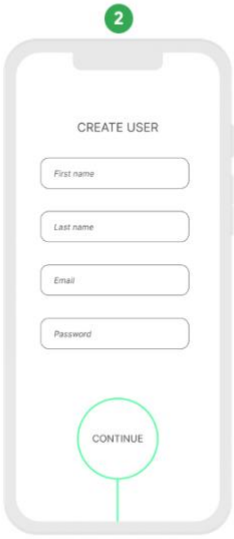
A reservation app for EV users to reserve chargers when and where they need– especially targeting urban dwellers without at home charging access – to be created in collaboration with Copenhagen municipality as a *public-private partnership* (PPP).



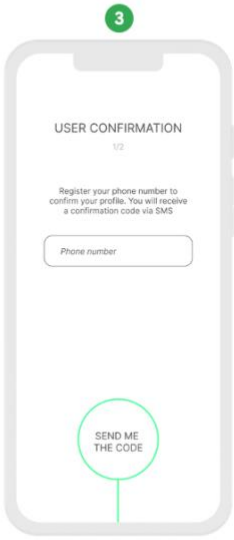
Visual representation



Log-in or sign-up

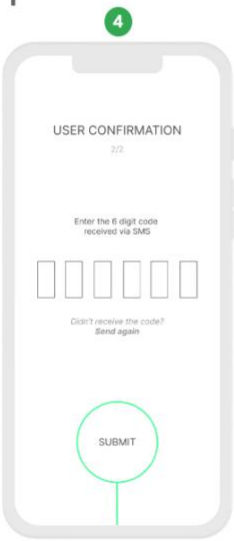


Create user page

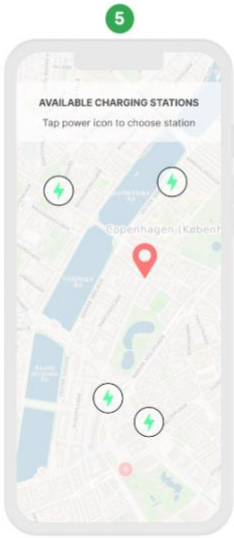


User confirmation

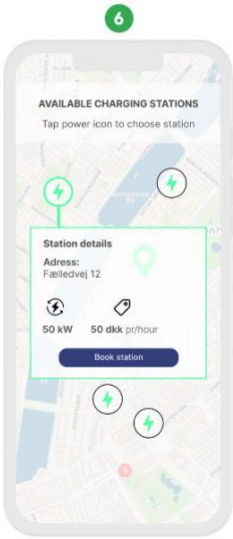
Visual representation



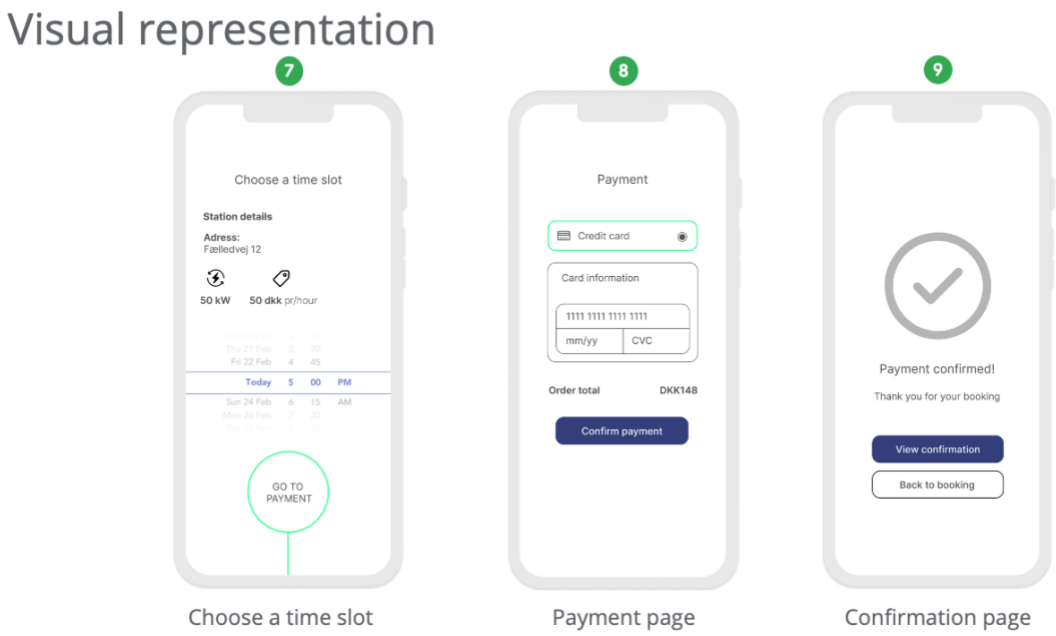
User confirmation

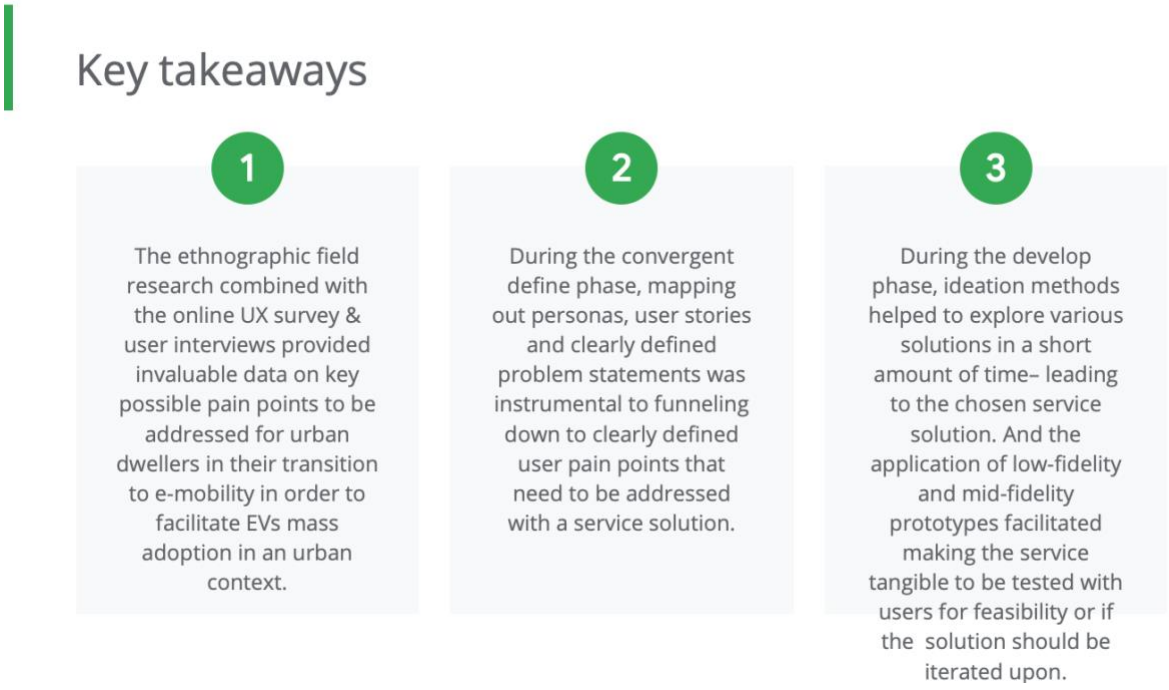


Available chargers



Charger details





Appendix 5—Transcribed interviews

https://docs.google.com/document/d/1pu6gKEHVLzmorbw0EqD5i6SHrcj2UugFYqX9s8ZGOK8/edit?usp=sharing