Public charging infrastructure as the key enabler for electric mobility in Germany: The future electric vehicle charging point and the provision of parameters for a sustainable business model concept

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"Leading energy into the future! – You never change things by fighting the existing reality.
To change something, build a new model that makes the existing model obsolete."

Richard Buckminster-Fuller | author, architect, inventor (Stenzel A., 2019)

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ABBREVIATIONS

ADAC	General German Automobile Club e. V.
AV	autonomous vehicle
BEV	battery-electric vehicle
B2C	business-to-customer
CAPEX	capital expenditure
CCS	combined charging system
CSO	charging service operator
CSP	charging service provider
CO2	carbon dioxide
COP	Paris climate conference, December 2015
DLR	Deutsches Zentrum für Luft- und Raumfahrt
e-cars	electrical cars
ELI	Electric Life | VW Group company
eMaaS	electric mobility-as-a-service
EMS	electric-mobility-systems
EU	European Union
FCV	fuel-cell vehicle
H2	molecular hydrogen
ICEV	internal combustion engine vehicle
LTE	long term evolution, mobile communications standard
MaaS	mobility-as-a-service
NPE	national platform for electric mobility
O&M	maintenance and other operational cost
OPEX	operational expenditures
PPP	public-private partnerships
R&D	research and development
SDG	sustainability development goals of the United Nations
SEMS	shared-electric–mobility-services
SUV	sport utility vehicle
UN	United Nations
WEF	World Economic Forum

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ABSTRACT

Electric mobility is enabling overall decarbonisation-targets by shaping a new, sustainable mobility. Related mobility behaviours are evolving rapidly and lead to fundamental changes within the respective infrastructure approaches. In doing so, public electrical charging is becoming a key prerequisite for the ramp-up of electric mobility. Yet there is still a lack of a nationwide public supply infrastructure in Germany because, at present, a profitable operation is not possible due to the volatile framework and low population. Hence, the comprehensive aim of this research project is the development of a sustainable business model for an electrical charging hub.

In order to define the parameters of an optimised business model, a mixed-measure approach was chosen. A combination of interviews, a survey questionnaire and a focus group-discussion integrate the field experts and their practical perspectives in the research. The literature analysis, especially, considers available benchmarking aspects. This primary data research and the literature analysis form the basis of a sustainable business model framework, to be developed in scope of this research project. It is not the purpose of this thesis to provide exact figures, but rather to contrive a framework with certain premises and estimations.

These wide-ranging mobility developments will also lead to innovative business models, which could transform mobility systems in the years to come. In particular, via the new “mobility-as-a-service-trend”, a recent concept is paving the way to provide one of the foremost solutions to today’s mobility challenges. Therefore, it seems that the possibilities for developing a sustainable charging station business, based on the keystone of future mobility, are definitely manifold. Main objective of this research project is to filter out how future mobility trends influence the business case of the future electrical mobility hub. The assertion is that the most promising approaches for charging station business cases are based on determined mobility behaviour. In this way, the so-called “chicken-egg-problem” between electric mobility rollout and charging infrastructure - as the key-enabler - could be solved. For this reason, anticipating customers’ new mobility preferences and requirements is of high importance. However, as is evident in this thesis, mobility-as-a-service is far from being achieved yet.

This research led to the empirical evidence that a sustainability focus can result in a profitable charging business model. However, this research is not only investigating a positive relationship between economic success factors and sustainable business models. The research is also demonstrating new business opportunities evolving in the field of electrical charging and mobility services, which would have remained invisible in a purely profit-oriented approach. Accordingly, the contribution builds upon business model perception and application unifying different sustainability dimensions and transferring the consolidated findings onto a conceptual levelling that facilitates more all-embracing interpretations.

Figure 1 | Intelligent transportation systems (Jenkins, 2019, p.18)

CHAPTER 1 | INTRODUCTION

1.1 Overall introduction

For some years now, “electric mobility” has been regarded as the major solution for future mobility (Fornahl & Hülsmann, 2016). “The dependence on fossil fuels and the climate change led not only in Germany to a debate on how the future of mobility might be designed” (Fornahl & Hülsmann, 2016, p.1). Concerning decarbonisation, “electric mobility” is one of the key aspects in this issue. Both battery-powered vehicles and fuel-cell vehicles support a sustainable mobility concept. These technologies enable eco-friendly and efficient mobility, because they are based on renewable energy sources (BMWI, 2018). Though this emerging path is still at the very beginning many developments are expected in the near future (BMWI, 2018), as electric mobility is a very powerful driver for further innovations. This “alternative technology” will impose some challenges, but electric mobility will in particular be a door opener to new engineering- and smart market approaches e.g. new vehicle lightweight construction with carbon fibre, battery solutions with integrated service packages or roaming in different electric grids (Losch, 2010; Dallinger & Wietschel, 2011). This will further intensify the innovative image of electric mobility and attract even more market players (Attias, 2018). Related developments are causing a rising demand for further innovations and for entirely new business model ideas. However, the transition to electric mobility is not only a radical technical change; it also means transforming mobility routines. This implies, for instance, that today a car driver goes to the gas station when there is the need to refuel. Now, referring to electric mobility “downtime” is as well a time for battery charging (Kane, 2015; Attias, 2018).

The European Union`s aim of reducing greenhouse gas emissions by 80%-95% by 2050 will result in a complete change of the mobility sector in Europe. Transportation today accounts for about 26% of the total European greenhouse-gas emissions, with a continuously increasing share (BMWI, 2020). Only via integration of low-emission mobility in this sector, can overall decarbonisation targets be achieved. These attempts also cover commercial vehicles and encourage the usage of electric vans or electric buses. Therefore, electric mobility has to redefine mobility and the automotive world in the near future and this will lead to fundamental changes respecting infrastructure approaches. According to a study by the Boston Consulting Group, electric vehicles will reach a significant market share by 2030 (BCG | Young & Reeves, 2020).
From a global perspective, China is currently about to become the overall market- and industry leader in electric mobility. Many new electric vehicle models have recently been launched (Tagscherer, 2018). In China, 1.2 million battery-driven vehicles were sold in 2019; 5.3 million electric vehicles are expected to be sold in 2025 and then 15.2 million electric vehicles in 2030, which would finally represent a market share of 40% by 2030 (Mizuho Bank, 2018 & 2019; Kords & Statista, 2020). To support these electric vehicle sales dynamics, China has quickly expanded its electric vehicle-charging infrastructure, with an increase of 118% year on year (McKinsey, 2017). Chinese car manufacturers such as BYD are currently

in a leading position with high production numbers for battery-driven electric vehicles (Perleberg & Clausen, 2017).
In parallel, are Chinese companies also entering the German market and are preparing the production of electric vehicles in Germany; major recent example is Borgward in Bremen (Perleberg & Clausen, 2017). Ucar, an emerging company in the Chinese mobility market, acquired a majority share of Borgward (Tagscherer, 2018).

Furthermore influenced by Tesla, Streetscooter and e.Go Mobile AG, this new development in the automotive industry is a steady upward trend (Handelsblatt Online, 2016; Tesla, Inc., 2019). Other countries are likewise moving ahead very quickly, for instance Norway and the Netherlands (Perleberg & Clausen, 2017).
Nevertheless, there is no automobile industry in these countries, that produces vehicles with internal combustion engines and would totally refuse a policy towards electric mobility (Perleberg & Clausen, 2017). By contrast, the German automotive industry is facing a dilemma. In order to complete successfully the transition from conventionally powered vehicles to alternative drive concepts, high investments are required. The European Union's threatened penalties are in the same range in case the product portfolio of low-emission electric- and hybrid models does not increase drastically in the coming years; of course despite the currently still low demand (Deloitte, 2020). Since, the classic car-production in Germany is highly developed and has matured over many years, a certain resistance to these changes is in a way evident. The German automotive industry has predominantly opted for the expansion of battery-powered e-mobility, which is currently the only available technology that enables rapid compliance with CO2-targets and thus the avoidance of EU-sanctions. The fuel cell has now reached a level of technological maturity that justifies its widespread application, despite further optimization requirements (Eaves & Eaves, 2004). However, comprehensive investments, e.g. in a charging station network and continued governmental support are essential prerequisites for further boosting the electric mobility rollout in Germany (Micksch, 2017; Deloitte, 2020). The future course set by the German automotive industry in favour of electric mobility is correct and sustainable in the long term, but the process of transformation is only just beginning. For example, the BMW Group recently announced its intention to restructure its manufacturing network. By 2024, the production of diesel- and combustion engines is to be completely withdrawn from the main plant in Munich | Germany. Large engines will be relocated to the British plant in Hams Hall, while the smaller engines will in future be built entirely in Steyr, Austria (Deloitte, 2020). On the one hand, there is the risk of losing thousands of jobs, in the case of a too rapid restructuring of the German car industry. On the other hand, people are admiring Tesla and the speed with which the US electric car manufacturer is bringing innovations to the market, building factories and creating jobs – as well in Germany (BDEW, 2020).

In addition to that, more and more considerations are being made to completely halt the sale of vehicles with internal combustion engines. For instance Norway for 2030, the Netherlands for 2025, Great Britain, France and California for 2040, plus a number of major cities including Los Angeles (Muoio, 2017).

Almost all major automotive companies are currently engaged in bringing new electric mobility solutions to the market. Nowadays German automotive manufacturers are producing 38 different electric vehicle models (Bohnsack et al., 2019).

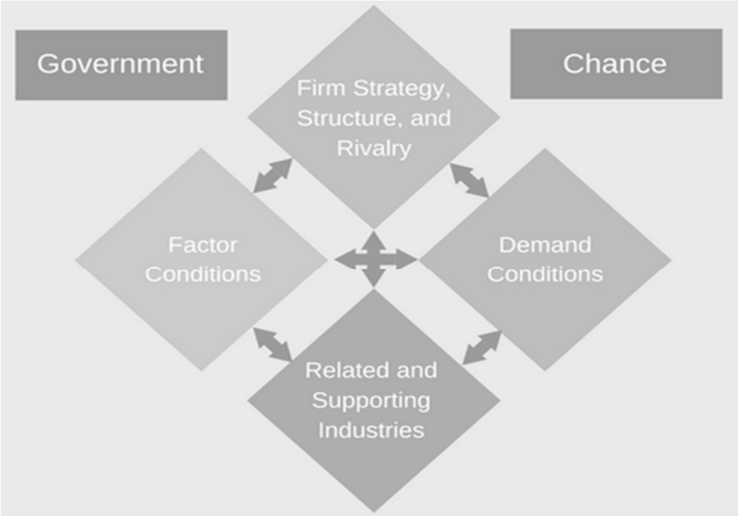
A lot has been achieved in the past few years. In most markets, besides some exceptions (e.g. China), German car manufacturers are gaining at least a comparable market share with their electric vehicles as with their conventional cars. Numerous patents in the field of electric mobility originate from Germany (BCG | Young & Reeves, 2020). However, in order to maintain the high market momentum, these efforts must not slacken. Germany itself also has to continue the national rollout of electric mobility and electrical driving. Against this background, Germany was chosen as the country showcase. Activities in these areas have progressed differently in the individual countries; depending on the political and economic framework conditions. But the path is mapped out: more and more people worldwide will drive electrically.

The German Government originally predicted that there would be one million electric cars on German roads by 2020. However, this ambitious target is still a long way off as is. In addition, the next higher target is far from being achieved easily, because within the next ten years the number of electric cars is expected to rise to 7-10 million electric cars by 2030 (BCG | Young & Reeves, 2020). The overall goal is to push the development of a comprehensive German electric mobility strategy further. Meaning encouraging urban electric driving and in parallel an electric mobility rollout in rural areas.

Having said this, the German Government has adopted an initiative to promote electric mobility in Germany. This includes for instance an environmental bonus for purchasing electric cars and funding the expansion of the charging infrastructure (NPE, 2015). As part of the COVID-19-economic recovery package, the German Government has even extended the purchase bonus for e-cars. Anyone who buys or leases an electric car can now expect a governmental bonus of up to €9,000 instead of the previous €3,000 (BDEW, 2020). The clear focus of the German Government is to achieve the lead international position of the German automotive industry in electric mobility. Hence, research- and development activities are encouraged by various governmental programmes (Attias, 2018). Nevertheless, “it is worth indicating that, the aspired technological leadership of Germany with regards to electric mobility requires a rapid growth of the national sales market” (Perleberg & Clausen, 2017, p. 5).

In this regard, Porter`s Diamond (figure 2) is often referred to the “Competitive Advantage of Nations” (Porter 2001) and displaying their competitiveness. According to Porter a national industry can only be fully competitive in case four national key attributes are favourable configured. Thus, the four corners of the diamond are each subdivided into a variety of indicators. Government and chance are introduced as additional factors that influence the four corners of the diamond (figure 2) (Porter, 2014). Only a perfect combination of key- and additional factors shape sustainable growth and national competitiveness. This refers to the following factors: government and factor conditions, related and supporting industries and demand conditions. Demand conditions indicate the need for an increased German sales volume for electrical cars, which are domestically produced (Porter, 2014).

Figure 2 | Porter`s Diamond Model (Porter, 2014, p. 21)



Concerning the electric mobility rollout in Germany, electrical energy, hydrogen and natural gas have so far lacked a nationwide public supply infrastructure. Because of this, the overall extension of the related charging infrastructure is also part of various government support programmes. At present, a profitable network of charging points is not possible; for this reason, related projects are financially supported in the context of funding programmes (BMWI, 2019). The technical framework for charging infrastructure is covered by the “European Directive on Infrastructure for Alternative Fuels” and the “German Charging Station Ordinance”. These regulations for the installation of charging technology therefore also assure investment security (Bräunl, 2013; NPE, 2018).

Currently in Germany, there are about 16,700 public accessible charging stations for battery-driven vehicles (rapid- and fast charging). According to estimates of the National Platform of Electric Mobility (NPE, 2018), there is a clear need for an immediate expansion of charging points up to 77,000 public charging stations in Germany. Without this, electric mobility targets cannot be fulfilled. Consumers rank the inadequate access to efficient charging stations as the third most important barrier to electric vehicle purchase and further electric mobility ramp-up (Burton, 2013; McKinsey, 2017). This is in accordance with McKinsey’s consumer survey 2017, which focuses especially on potential customers for battery-powered electric vehicles in China, Germany and the United States (McKinsey, 2017). “With electric vehicle prices declining and ranges expanding, charging could soon become the top barrier” (McKinsey, 2018a, p. 2ff) or the most important enabler for electric mobility in Germany (Braga et al., 2017). For further explanations, see figure 3, showing status-quo of charging infrastructure.

Figure 3 | Current European breakdown of public charging (Lucien, 2020, p. 16)

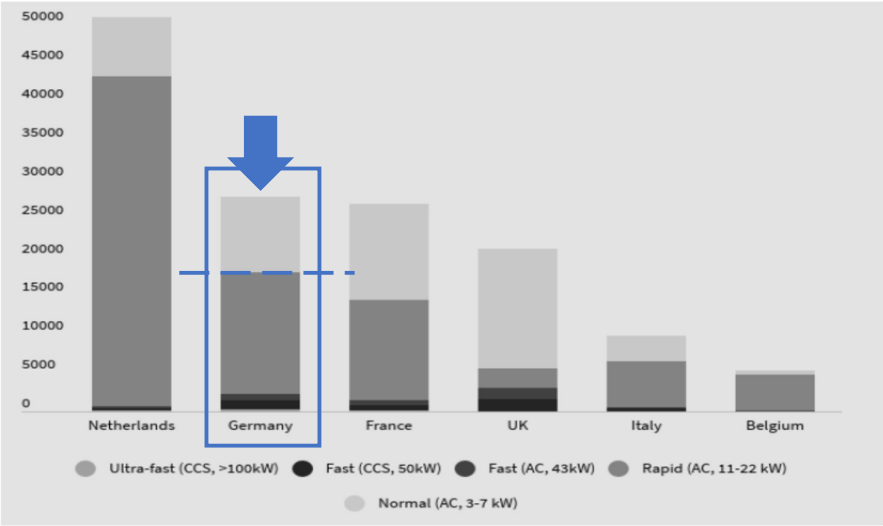


Figure 3 illustrates the different maximum charging power ratings. This is depending on grid connection availability and connector type. Some European countries seem to rely more on fast charging, others rely largely on rapid chargers like the Netherlands. The Netherlands and Germany already benefit from good coverage: more than seven fast charge points for every 100 km; while some other countries (e. g. France, Belgium) have acceptable coverage with four to seven fast charge points per 100 km on average. On the contrary, the overall density of chargers is still relatively low and not sufficient at all for the intended electric mobility rollout (Lucien, 2020, p. 16).

Currently, an important factor in this discussion within the VW Group is the foundation of its own green electricity company – called “ELI | Electric Life”. As from early February 2019 onward, anyone, whether a VW customer or not, can buy green electricity from ELI. To this end, a portfolio of intelligent electricity tariffs, charging stations and an IT-based energy management system was established during the course of 2019 (Business Insider; 2018). VW wanted to create an offer, which “reliably” responds to all the energy issues of e-car users, including the expansion of the required charging infrastructure (VW Group, 2019). “It is about complete climate-neutral mobility – from the supply chain and production to green charging electricity and finally recycling” (VW Group, 2019, p. 2ff). “The magic wording here is as well “smart grid” – bidirectional connectivity between cars, homes and the electricity grid. This is the next building block in Volkswagen’s integrated electric mobility strategy” (VW Group, 2019, p. 2ff). Nevertheless, the manufacturers and suppliers of the combustion engine are still in a very strong position, with extremely powerful conjunctions.

Just recently, Volkswagen was astonished that Deutsche Post | DHL really wanted an electrically powered delivery vehicle, and the Deutsche Post | DHL then set it up independently with a start-up from the University RWTH Aachen (Perleberg & Clausen, 2017, p. 5-18). At that time, Volkswagen put Deutsche Post off until five or ten years from now, when the necessary developments of the electric

drive would be ready for series production (Dohmen & Hage, 2016). However, the Streetscooter should become a success story in a timely manner.
Because of this, a start-up from Aachen has made delivery traffic more environmentally friendly under the umbrella of the venerable Deutsche Post. The company is now using 11,000 of the battery-powered vehicles, so that it can deliver postal items with zero emissions, at least for the last mile. However, production of the Streetscooter will end in 2021. The main reason are missing automotive partners and that for the long run the Deutsche Post clearly propagates that they do not want to be in parallel a car manufacturer (Lucien, 2020). “Even today, according to KPMG, 54% of the European managers still expect the electric car to fail. The majority of the managers represents the opinion if ever; it will only be the fuel cell, which leads to the sustainable breakthrough of electric mobility” (Perleberg & Clausen, 2017; KPMG, 2018, p. 27ff).

Currently the economic impact of the COVID-19-crisis is extremely difficult to evaluate. Maybe related negative effects on the world economy will significantly slow down the ramp-up of electric mobility in Germany. The current crisis means that the target of 10 million vehicles with alternative drive systems by 2030 is unlikely. In particular due to the fact that consumers are currently postponing a car purchase, because of the high economic uncertainty. However, through strategic interaction between politicians, industry and consumers, the current situation could be actively used to drive the change even more decisively (Deloitte, 2020). In a survey of the consulting company Deloitte, amongst German large and medium-sized enterprises, the COVID-19 crisis is even likely to accelerate changes in the automotive industry and facilitate an early breakthrough of electric mobility. “We must and we will learn a lot from the COVID-19 crisis and adapt our behaviour accordingly - to avoid future crises, but also to take advantage of the opportunities that can also be learned from these drastic developments” (Cristescu, 2020, p. 3). Electric mobility, in particular, also benefits from the economic stimulus package put together by the German government (Deloitte, 2020). Given that the far-reaching consequences of the COVID-19 crisis are, yet, unknown this DBA thesis cannot integrate them into its argument.

Against all these wide-ranging developments, the present thesis considers, in particular, the main research question about “how parameters and key criteria for an optimised business model for electrical charging hubs should be designed”.
The arising overall research aim with regard to the provision of public charging infrastructure is the achievement of a sustainable business model.
The following objectives are embedded to meet this research aim:

1. Evaluating future mobility trends and their influence on sustainable charging business models.
2. Investigating the new role of the public charging station – being a mobility hub.
3. The development of a final scenario definition, which represents various electric vehicle-charging alternatives in terms of charging technology or charging station services, in order to design a profitable business model.

It is not the aim of this thesis to provide exact figures, but rather to develop a framework with certain premises and estimations for the potential of public charging based on robust data sources and assumptions.

Current discussions indicate that there is, in general, a clear necessity for electric mobility to achieve a better market penetration in a timely manner through new business- and service model definitions within a company`s future corporate strategy (Arthur Little, 2015). The intended business model should consider service-based operations and ownership rights concerning a life cycle orientation and sustainable business success. This refers to redefining how enterprises think about energy – offering "energy as a service" and flexible consumption models "pay per use" (Navigant, 2017, p. 1-6). Charging infrastructure is closely related to power generation, the power grid and the energy turnaround. Due to this, all these issues are to be integrated in the research considerations, but the focus will be set on public charging points in Germany and the parameters for a sustainable business model concept (Navigant, 2017), which takes into account the challenges of the technological status-quo (Green eMotion, 2015; DNS, 2020).

To address the research question, the literature analysis will consider business model concepts in the overall market and enrich them via available benchmarking aspects (Kunz, 2016). This takes into account existing business models from other industries and illustrates the very few available options for charging infrastructure. Premises and advantages of successful service concepts are incorporated into the research and are an important basis for the research project. Because of this, the primary data collection process starts here and integrates different perspectives from various field-experts, with heterogeneous industrial backgrounds (Kunz, 2016).

Thus, the initial stages of primary data collection, embrace interviews and a survey questionnaire. As this is a new topic, it is extremely important to integrate the field experts and their practical perspectives on the research together with the intended proceedings. Practical research is intended to make a central contribution to gaining knowledge within the framework of this thesis. The aim is not to declare one of the forms of knowledge - theory or practice - to be the dominant one. Rather, it is therefore the aim of practice research to find mutual connections between professional practice knowledge into the context of disciplinary knowledge, and vice versa. Clear ambition is to enrich scientific knowledge out of practice. Through this approach and the involvement of experts, the intention is to gain the latest insights for an emerging new field of research.

By means of the brief interview series at the beginning, the intention is to narrow the complex topic down and to define the main pillars for the follow-up questionnaire. The final input of practitioners is incorporated via the focus group session. The primary data research and the literature analysis form the basis of a sustainable business model framework.

An emerged criteria catalogue for a sustainable business model and best practice approach for new charging infrastructure are the groundwork for this proposed framework. A comparison of the requirement catalogue with existing solutions on the market allows the identification of potential interfaces as well as the differentiation of the project. In order to achieve in-depth research about e-mobility business models, the background of the sustainable business model is summarized in general and is transferred to the context of electric mobility and charging. This proceeding focuses on the area

of the charging infrastructure and verifies any dependencies e.g. on the vehicle, battery or the system services.
The acceptance of electric mobility clearly depends on a public charging infrastructure adapted to customers` needs combined with a positive customer experience while charging (Ligen et al., 2018). Bearing this in mind for the whole research project, the optimal business model will be investigated.
Finally, it can be emphasized, that the all-embracing availability of public charging stations is a key factor for consumers' acceptance of electric vehicles. In the scope of a short-term measure portfolio, it is extremely important to build up the charging infrastructure in a systematic manner, in order to prepare the sales market for launching numerous electrical models in particular from major German manufacturers (Clausen, 2018).

After setting out the topic in this introduction, the overall research aim, the intended research proceedings and main objectives per chapter are summarized in the following overview | 1.2.

1.2 Research aim and relating thereto objectives

To illustrate the overall research question, the research aim and the central key objectives, the following overview was chosen. This illustration serves as an orientation guide for readers of this empirical work and the research process.

Figure 4 | Research question, aim and objectives I (own illustration)

The present thesis considers, in particular, the main research question about "how parameters and key criteria for an optimised business model for electrical charging hubs should be designed".
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It is not the aim of this thesis to provide exact figures, but rather to develop a framework with certain premises and estimations for the potential of public charging based on robust data sources and assumptions.

Figure 5 | Research question, aim and objectives II (own illustration)

	Content overview per chapter and research process
1	**Introduction** • Providing a first impression of the multidimensional impacts of the new mobility concepts and technologies.
2	**Background and research object – electric mobility and charging** • Explaining public charging infrastructure, the central research object of this thesis. • Addressing current obstacles of a profitable business case and the “chicken-egg-problem”.
3	**Literature review and research gap** • Public charging infrastructure = a clear enabler for the future electric mobility rollout and overall acceptance of electric mobility. • Results in the necessity to consider the topic of business model innovation as a sustainable approach for public charging infrastructure. • The focus of “mobility-as-a-service” concepts is to promote electric mobility by facilitating intermodal travel. These aspects need to be further investigated, to enable a sustainable business model for the future electric mobility-charging hub. • Reviewing the literature-portfolio to meet these objectives.
4	**Research philosophy** **Study design, research methodology, research methods** • Defines the philosophical stance and portfolio of research methods to be applied; consequentially consider the overall research aim.
5	**Primary data collection, analysis** **Answering research question** **Contribution to theory and practical relevance** • Elaborate the primary data collection and related analysis. • Highlight the most important findings and focusing to answer the research question: “How parameters and key criteria for an optimised business model for electrical charging hubs should be designed”.
6	**Conclusion and outlook** • Charging operators are leveraging their service portfolio with multi-modal mobility offerings. • Therefore, it is demonstrated, that it is worth exploring in much more depth as an ongoing ambition, the manifold factors influencing the business model sustainability of a future-charging hub.

The introduction to the research topic should provide a first impression of the multidimensional impacts of the new mobility concepts and -technologies. As already indicated, various stakeholders, in business, research & science and on governmental side, comprehensively promote the rollout of electric mobility solutions. For example, the German Federal Government is also funding the electric mobility implementation with a wide-ranging set of measures. This support also encourages the further expansion of public charging infrastructure by private charging operators.

The above-mentioned summary is the starting point for the further thematic exploration of the topic of electric mobility and charging infrastructure in chapter 2.

CHAPTER 2 | RESEARCH BACKGROUND, ELECTRIC MOBILITY AND CHARGING

In the following chapter 2, general principles of electric mobility will be explored at first. This is supplemented by explanations on the public charging infrastructure, the central research topic of this thesis. Considering these introductory words, the following section first investigates the current trend towards electric mobility, including an outline of the central drivers and the main barriers. Germany is taken here as an illustrative example, amongst other countries also rapidly developing electric mobility. The issue is analysed, which role a public charging infrastructure will have in terms of a nationwide rollout of electric mobility solutions in Germany. The emerging query is to what extent public charging solutions do have an enabler role in the overall electric mobility rollout in Germany and how the related chicken-egg-problem could be solved. Without a public charging infrastructure, the usability of electric cars remains only limited and purchasing figures will of course be rather low. However, the development of the charging infrastructure today requires investments in a market that will at best be large enough to allow refinancing in a few years.

2.1 The outlook for electric mobility in Germany

2.1.1 Main drivers and current trends

Various authors have investigated main drivers and current trends around electric mobility. For instance, Kirsch and Dijk see the “Clean Air Act” in California as a main catalyst for electric vehicles and worldwide decarbonisation (Kirsch, 2000; Dijk et al., 2013, p. 145). According to Mazur and colleagues (Mazur et al., 2015) or Arthur Little (2019), a driver is even, that various countries were legally binding zero carbon-emission targets. Examples are the very strict and first-time approach of the United Kingdom until 2050 or the German approach with less stricter long-term regulations. For instance in doing so, Britain became the first G7-country moving towards curbing climate change at such a scale.

Key influencing factor is as well the recent megatrend “urbanization and smart cities” with the consequence of an increasing number of individual journeys undertaken (Arthur Little, 2015). Besides Arthur Little (2019) lists the far-reaching measure portfolio by various governments to push decarbonisation, e.g. purchasing bonuses and tax reliefs. In particular the intensified car-sharing activities are also boosting electric mobility (Arthur Little, 2019). Finally Dijk et al. (Dijk et al., 2013, p.135) see electric cars as clear enabler of the energy transition. By means of smart grid-based systems for electricity management, e-car batteries can be used in order to store energy for electricity suppliers, balance renewables and strive for related Sustainability Development Goals (United Nations, 2020).

In its entirety, electric mobility is fostering the Sustainability Development Goals (SDG) defined by the United Nations. Energy and related mobility shall become more sustainable and widely available (United Nations, 2020). Recent trends and developments suggest that the breakthrough of electric mobility could come faster than formerly expected (Wildemann, 2018).

2.1.2 Overview of electric mobility solutions

The German Federal Environment Agency is considering passenger car drives “as a continuum, from the conventional drive by internal combustion engine, via various hybrid variants, to the battery powered electric vehicle and the fuel cell vehicle” (figure 6) (Perleberg & Clausen, 2017, p. 8; BMWI, 2018). Simple hybrid cars, improved gasoline and diesel engines do not, at the end of the day, contribute to climate-neutral car drives (Klima Allianz Deutschland, 2016). The group of plug-in hybrids and natural gas vehicles, on the other hand, is more likely to “reduce average energy consumption and emissions in a transitional phase” (Perleberg & Clausen, 2017, p. 8). According to the project study, “Evolution2Green” the key terms on the subject area of electric mobility were defined (Clausen, 2017). Referring to these key definitions battery-electric vehicles (BEV) and the hydrogen-powered fuel cell vehicles (FCV) are classified as pure electric vehicles and, therefore, these two technologies are the main focus of this research and the intended new business model for a suitable public charging point (Clausen, 2017; Themaa et al., 2018).

Figure 6 | Various types of electric mobility (following Götze & Rehme, 2011; Plankenauer, 2012)

Degree of electrification regarding the powertrain					
-		**+**		**++**	
Micro-Hybrid	**Mild-Hybrid**	**Full-Hybrid**	**Plug-In-Hybrid**	**Hybrid with range-extender**	**Full electric vehicle**
Start-stop automatic	Recuperation, acceleration support	Purely electric driving	Charging via power-grid possible	Internal combustion engine only for charging the battery	Pure electric engine
Various energy storage solutions					
Multi-store hybrid systems		**Fuel cell vehicle**		**Battery vehicle**	

2.1.3 Barriers towards an overall electric mobility rollout

Barriers towards an overall electric mobility rollout are summarized via the following overview (figure 7). Further details are listed in the appendix.

Figure 7 | Barriers towards an overall electric mobility rollout (own illustration)

Schroeder & Traber, 2012	• Range anxiety and range envy - mobility patterns: charging at low power connection rates is sufficient, public charging infrastructure is only for sporadic usage (BEV) during driving outside regular trip profile in order to overcome range anxiety and range envy
Madina et al., 2016	• Electric cars are still quite expensive
Perleberg & Clausen, 2017, p. 9	• Fuel cell still far from an overall breakthrough - relatively insignificant technology for a longer time to come
Romare & Dahllöf, 2017	• Need for eco-efficiency in battery production of Li-ion batteries and a full life cycle assessment
BMWI, 2018	• Currently long charging times and the short battery range for battery-driven electric cars
Damm, 2018; Bohnsack et al., 2019; Funke, 2019	• Lack of charging infrastructure and charging technology for electric vehicles has been equipped with different designs worldwide

➔ In terms of customer acceptance, electric mobility has to compete against the embedded traditional car industry with its “highly developed infrastructure and wide consumer confidence” (Serradilla, et al., 2017, p. 516). In addition, the prerequisites for overcoming all barriers are profound changes in these electric mobility-technologies and roles in the value chain (Madina et al., 2016).

➔ “This points the way to an electric mobility, in which the tiresome discussion about charging infrastructures dissolves and focuses itself on a necessary conversion of the filling stations on motorways into fast charging stations” (Clausen, 2018, p. 16).

➔ Successful example here is TESLA. TESLA`s electric car sale is very well promoted by its “Supercharger Network” and offering the parallel access to a far-reaching charging network. Other electric car manufacturers have not provided this guarantee for electrical charging so early and wide-ranging; main reason are the high initial investment. Nevertheless, TESLA gained a unique selling proposition by emphasizing the company’s clear commitment to electrical driving via the Supercharger Network (Tesla Motors Inc., 2013).

2.2 Object of investigation – clear need for public charging infrastructure in Germany

2.2.1 Overview of charging applications

Battery-driven vehicles | BEV and related battery charging technology
Fuel-Cell vehicles | FCV and related hydrogen charging technology

To provide a technical background for this analysis, this section gives a very brief overview of charging station technology, standards and basic terminology. This information is required for a more general understanding. Because of this, further explanations are directly linked to the appendix.

2.2.2 Public charging infrastructure as key enabler for electric mobility

The future of electric vehicles depends on a widespread public charging infrastructure in order to recharge batteries or refill hydrogen tanks. Current research indicates that this is one of the most important pre-requisites for the further acceptance and rollout of electric mobility solutions in Germany (Proff et al., 2013; Klima Allianz Deutschland, 2016). Several studies claim that with a nationwide charging infrastructure, the acceptance of electric vehicles and thus the willingness to drive electrical will increase significantly (Ligen, et al., 2018; NPE, 2018).
In parallel conventional refuelling stations are still needed for internal combustion-engine vehicles (Ligen, et al. 2018). Nonetheless new charging stations cannot simply be combined with the conventional gas stations, as e.g. BEV take a longer time for charging, which may hinder the charging of vehicles with internal combustion engines, due to space limitations (Abdalrahman & Zhuang, 2017).

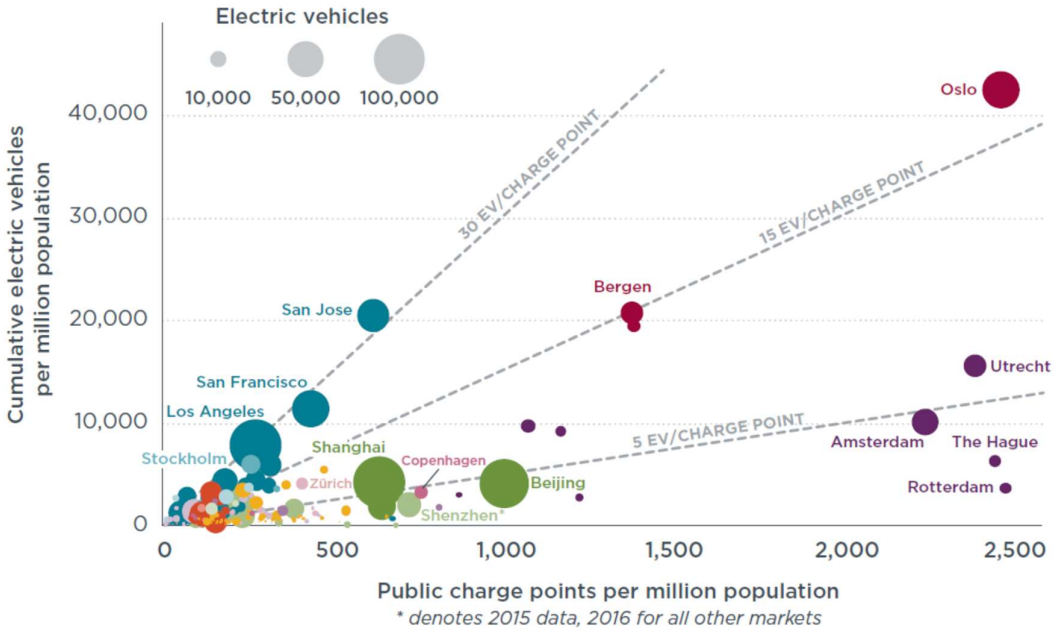
When battery electric vehicles | BEV and fuel cell vehicles | FCV are compared, it becomes clear that they are not equally impacted by this issue.
For BEV several charging options are available (Ligen et al., 2018). This means BEV can be recharged at home or at public charging stations. According to recent estimations, 80% of the charging activities are done at slow charging rates at home or at the workplace (Ligen et al., 2018). Electric vehicle drivers are expected to be the early adopters, when charging at home. The reason is that there is an improved total cost of ownership through incentives for buying e-cars and charging at home at lower prices overnight (Madina et al., 2016).
Fast charging approaches only account for 20%, especially due to longer stops for charging during a journey, higher charging costs and a lack of charging infrastructure (Ligen et al., 2018). Ongoing research clearly emphasizes that public charging infrastructure has to be expanded as an important prerequisite for an overall electric mobility ramp-up. Public fast charging for battery-driven vehicles is a premium service, assuring comfort and reliability for all travel activities. The pricing for fast charging is not just based on the energy; it also has to factor in the high initial investment required for charging stations, installation costs and grid transmission capacity.

The two charging types – private charging and public charging – are connected to two different types of charging infrastructure (Madina et al., 2016). Each type of use will be valued by electric mobility users, under various criteria.
For private charging price-competitiveness is of high importance, e.g. in order to compensate the higher vehicle price. Against this, convenient charging offers an extension of the normal driving range, respectively overcoming range anxiety / -envy and therefore the customer base is likely to pay slightly more. However, in parallel to these thoughts, the electric charging price level always has to be similar or even cheaper to the case of charging a combustion engine vehicle (Madina et al., 2016). In addition, higher power charging would make long-distance much more convenient for BEVs by assuring refuelling times similar to internal combustion engine vehicles | ICEVs. Rapid charging with powers at ~400 kW or higher, would even enable a significant driving range in a period of 10-25 minutes (Dericioglu et al., 2018).

FCV are refilled at hydrogen refilling stations. For FCVs the charging only takes a few minutes, but the challenge here is, that there are only a few public charging stations available and due to the necessity of careful hydrogen handling, recharging at home is normally not possible (Ligen et al., 2018).
Despite all electric vehicle- and fuel cell improvements entering the market, there is still a scarce H2-charging infrastructure and an issue with first fragmentation, data availability besides a lack of consistent standards in most markets (Hall & Lutsey, 2017a). As of June 2019, there were around 100 public hydrogen-charging stations in Germany, with a clearly upward trend. In addition, there are further filling stations, e.g. owned by companies, such as the Daimler Group and the Linde Group, which have built up several hydrogen filling stations, almost independently of existing vehicle numbers.

In order to make electric mobility in Germany much more attractive, politicians, vehicle manufacturers and investors must achieve a unified opinion for an accelerated rollout of electrical charging infrastructure. Current efforts are very heterogeneous and the number of charging points is no longer adequate for the desired German ramp-up. More has to be done to improve usability and accessibility, or to simplify payment (Agora, 2015). Additionally, there is a clear need for automotive companies to provide information about future charging possibilities for end-users and about the operation of charging infrastructure (NPE, 2015). Therefore resilient business models and further analysis are needed to integrate private investors into the expansion and overcome range anxiety and range envy for electric mobility users. Eliminating range anxiety and range envy by giving consumers the confidence that they can recharge quickly where necessary, regardless the electric vehicle model, is of highest importance (Serradilla, et al., 2017). For further information, see figure 8, “public charging infrastructure and electric vehicle registrations by metropolitan area”.

Figure 8 | Public charging infrastructure and electric vehicle registrations per million population by metropolitan area (García et al., 2019, p. 18)



2.2.3 Overcoming the “chicken-egg-problem” of public charging and further shaping the overall research aim

Interdependencies between the availability of public charging infrastructure and the purchase of electric vehicles is often referred to as a “chicken-egg-problem” (Proff et.al, 2013; McKinsey, 2017). This phrase is derived from the philosophical question “Which came first, the chicken or the egg?”, and this poses a dilemma due to its circular dependency (Wirges, 2016). In terms of the large-scale development of the electrical refuelling infrastructure, the following problem arises: The demand for electric cars is still relatively low, so that no economic equivalence to established passenger cars exists at all. Without a sufficient number of potential customers, no investor is ready to build the required infrastructure. Without a nationwide infrastructure, vehicle manufacturers will not be able to successfully establish enough electric vehicles on the market. This blocking effect is often named a chicken-egg-dilemma, where none of the two parties acts, waiting for the other (Proff et.al, 2013; McKinsey, 2017).

Harrison and Thiel determined that there is a strong correlation between electric vehicle market share and the availability of charging infrastructure. They could substantiate the interdependencies in scope of several studies. According to their research, electric vehicle market share increases as the electric vehicle / charge point ratio decreases from 25 to 5 electric vehicles per charge point (Harrison & Thiel, 2017). For instance, the experiences in Norway show an impact on uptake once electric vehicle stock share exceeds 5% (Figenbaum & Kolbenstvedt, 2016; Harrison & Thiel, 2017). Other analyses from Hall and Lutsey (2017b) also assessed the interdependences between charging infrastructure and the number of electric vehicles. However, these scientists focused on the 50 largest metropolitan areas in the United States, breaking down charging infrastructure at a regional level. Overall, their research verified a considerable relationship between public charging and electric vehicle uptake and identified 275 charge points per million residents as a benchmark for leading U.S.-markets (Hall & Lutsey 2017b; Harrison & Thiel, 2017). Hall & Lutsey summarized in its entirety that a robust electric vehicle market requires multiple types of supporting policy and -instruments. This encloses charging infrastructure, consumer incentives and addressing consumer awareness barriers, e.g. range anxiety and range envy issues (Helmus et al., 2018).

In a free market economy, the customer decides which products are successful through their purchases. Several criteria count for this purchasing decision, in addition to the cost structure thus; especially the user-friendliness is of high relevance. An electric vehicle cannot be operated without “fuel” - if there is no charging station, the vehicle is so to say "useless". The customer must therefore have a fuelling option available from the time of purchase. An electric filling station that is used only marginally is uneconomical, but it is operational and offers many stakeholders the possibility to refuel with electricity or hydrogen (Harrison & Thiel, 2017). In most cases, an existing charging infrastructure provides the decisive argument for electric vehicles to be purchased. Ideally, government and industry coordinate the operation of electric filling stations with the deployment of e-vehicles. In this way, charging station operators can rely on a certain sales volume and electrical drivers can count on a secured supply. Existing filling stations thus create immediate downstream demand for electrical car sales.

Therefore, many authors see the solution to the chicken-and-egg problem in the initial provision of the charging infrastructure, which is the only way that positive impulses for the electric vehicle market can follow (Helmus et al., 2018).

In terms of the chicken-egg-problem of public charging infrastructure, also the fundamental question arises: How should mobility investment be financed in general, via tax revenues or through user payments and fees. Mobility is a major prerequisite for a modern society and for international markets. However, the establishment of a nationwide mobility infrastructure is always very expensive and a long-term, high-risk investment. Mobility infrastructure is therefore often a "natural monopoly" and its provision is primarily a public obligation (Helmus et al., 2018). For reasons of efficiency, German transport infrastructure is predominantly financed from general tax revenues and is made available "free of charge" (Bardt et al., 2019). The decisive factor for the government is to ensure that the publicly provided good is made available in the best possible way and not to maximize its revenues. Nevertheless, mobility infrastructure provision is not a governmental task in every case. For instance in Germany, the financing, construction and maintenance of the highways is usually the obligation of the German Government. However, the Ministry of Transport is implementing private-sector operator models on various motorways, where, for example, construction, operation and maintenance are assigned to private-sector companies for a certain period. Considering this, mobility is a mixture of private and public values. This is also valid for financing. Private- and public investments are closely related, sometimes even complementary to each other.

The same applies to electric mobility infrastructure (Gnann et al., 2015). As there is no nationwide recharging network, no one is encouraged to buy an electric car. However, as long as there are no electric cars, there will be no private investment in the provision of charging stations. To overcome such a "chicken-egg-problem", some governmental engagement is necessary at the very beginning as a starting point. The development of the charging infrastructure today is related to a market that, at best, will be large enough to allow refinancing in a few years' time. Although the German government is already supporting the public charging stations with up to 60% of the investment costs, other initial funding possibilities have to be elaborated. As especially in the case of network technologies, i.e. those that require a specific infrastructure to be used, market failures can occur. Demand only arises when a sufficient infrastructure exists (Bardt et al., 2019).

Infrastructure serves as a universal input factor and is rarely tied to a single use, but rather represents an input for various economic- and social activities. Large infrastructure investments are typically carried out or are at least planned by the public sector. While smaller projects can also be handled by private companies. Current major example for large infrastructure investments in Germany is not only the electrical charging infrastructure, but also the broadband expansion. High-quality, efficient mobility infrastructure and communication systems are crucial for the successful economic development of a national economy. The expansion of the 5G optic-fibre network creates the conditions for smart city concepts, optimises “Industry 4.0”-applications and enables sustainable mobility. Moreover, digital- and electric mobility infrastructure in particular are increasingly paving the way for innovative technological applications and new business models.

In Germany, the picture is quite ambivalent in both infrastructure fields. There is a notable analogy between the expansion of the new mobile communications standard 5G and electric mobility, which is subject to a similar chicken-and-egg problem (Bitcom, 2019).
In the context of a digital infrastructure, data centres and internet nodes are available in sufficient quantity and quality. In an international comparison, Germany lags behind in terms of fibre optic coverage on the "last mile" (FTTH/B connections) (Bitcom, 2019). In addition, mobile phone coverage with LTE, the most modern standard to date, is not available throughout the country. Finally, there are rural regions, where even basic mobile communication is not guaranteed. Subsidies for broadband expansion must be stabilized. Governmental investment support should be prioritized, where expansion is uneconomical for private investors.
The central uncertainty factor with regard to connecting end-customers is that it is not possible to foresee today which new services will become possible in the future and how the demand for corresponding broadband-access will develop. Of course, all companies that offer innovative products face such a market risk. On the other hand, experience shows that dynamic governmental regulation can be successful without significantly restricting competition. The mobile communications standard 5G, whose market launch is expected to begin on a larger scale from 2021, will technologically offer transmission rates of up to 10 Gbit/s with higher reliability and negligible delay rates (BREKO, 2019). Thus, large data packets can be transmitted almost in real time, which is a key factor for many innovative applications and business models. Besides these new infrastructures are increasing the productivity of companies and reducing transaction costs. Thus, infrastructure investments have multiplier effects that can hardly be predicted, as they go far beyond the optimization of existing technical applications and usage options. Even if broadband expansion in Germany is mainly a task for private-sector companies, public funding for broadband expansion is important to keep Germany attractive as a business location in international competition and to create equal living conditions between urban and rural areas (Helmus et al., 2018).

The profitability of broadband investments is determined above all by the population density within a given expansion area and the expected willingness of local households and businesses. This means that especially in poorer regions, in sparsely populated rural areas and everywhere where comparatively cheaper substitutes already exist, there is a threat of a "digital divide". Access to infrastructure services also has important distributional effects, as it has a disproportionate impact on the incomes and welfare position of the population. Connection to transport and communication infrastructure facilitates access to production and employment opportunities, increases the value of existing assets and improves both general information and educational opportunities (Helmus et al., 2018).
Finally despite the obvious “chicken-egg-analogy” and certain differences between the large infrastructure-segments of mobility and broadband expansion (BREKO, 2019), they also have another connecting element. Considering the explanations beforehand, they have a common ability for better economic- and social integration of society. Transport infrastructure and digital infrastructure create "connectivity", either physically in the sense of mobility connections or virtually in the sense of data- and communication connections. In particular, those special characteristics make the solely marked-based provision of such infrastructure-services and new technologies difficult.

The requirement of at least temporary governmental intervention arises. Public institutions enter the scene as either owners, investors or regulators (Gassmann et al., 2018).
Besides there are further special characteristics existing, which lead to governance-requirements:

- Technology-related infrastructure investments are always accompanied by high fixed costs, the extent of which is independent of the actual subsequent intensity of use. In addition, most of these expenses fall into the category of "sunk costs". Thus, when the project is abandoned, the construction costs usually have to be fully depreciated (Gnann et al., 2015).
- Economies of scale due to "sub-additive" cost trajectories lead to "natural monopolies". Sub-additive cost trajectories mean that a single provider can supply the entire regional market at lower costs than would be the case if divided among several providers. For example, in terms of the fibreglass rollout, it is cheaper, if an efficient company connects in a particular area all the residents to a line. If other providers were to lay fibreglass and the connections were divided between them, this would lead to a cost-multiplication; the construction costs are increased without the performance being improved. State regulation of natural monopolies thus faces a fundamental conflict, if it relies on infrastructure competition and allows market entry. It is therefore always necessary to validate, if this can increase efficiency and stimulate innovation (Gnann et al., 2015).

Public charging points can only economize if they are subsidized. A charging infrastructure supplier will not be able to earn money with low-budget charging facilities until 2030 (Gnann et al., 2015). Economic theory promotes that economic efficiency of new technologies and infrastructure investments can be improved by matching the policy instrument to the market failure (Gnann et al., 2015; Chen et al., 2017). In general a sensible set of policies to address the market failures relevant to electric mobility has the potential to greatly improve economic efficiency and at the same time would have other benefits, such as achieving a sustainable mobility (Chen et al., 2017). Nevertheless, much future work is still necessary, to analyse the essential market failures and increase awareness for policy-development to best address these market failures. Janssen et al. (2006) describes the difference between market failures and market barriers. Market barriers integrate market failures but they also may involve various other disincentives. For example, high technology costs can be described as a market barrier but may not be a market failure.
Electric mobility policy is thus likely to require various policy instruments in order to address the different kinds of market failures. Amongst other examples, the provision of information is of high importance. Only via providing, enough information about the evolving framework of electric mobility and helping to preserve the environment may reduce the informational market failure (Chen et al., 2017).
A chicken-and-egg problem arises in particular, wherein multiple actors must simultaneously invest and ramp up production in order to commercialize a new technology. This may be most relevant in technologies that require a new infrastructure (Aldy et al., 2009). Such possibilities necessitate inter-industry cooperation and thus may greatly delay investments. Therefore, a sensible policy goal involves matching the most appropriate governmental intervention to this failure (Aldy et al., 2009). Finally, policy instruments can address given market failures. In order to achieve economic efficiency, they should be combined in an optimal way to achieve an overall net benefit.

Japan is setting a good example here: as part of its national hydrogen strategy, Tokyo is promoting the use of stationary fuel cells in buildings and the market penetration of hydrogen vehicles in transport, because neither the energy- nor the transport transition will succeed without the guiding intervention of the government.
Concrete targets for the development of a hydrogen infrastructure and the necessary investment incentives from the political side are required. To ensure that hydrogen does not remain an everlasting promise for the future, there is the need for an intelligent and courageous policy (Chen et al., 2017).

The conditions for the emergence and diffusion of innovations have long been the subject of scientific research. While classic research approaches were still strongly characterized by the idea that innovations develop in a linear and directed manner along certain phases (Bennear & Stavins, 2007), the view now prevails, that it is much more a discontinuous process. This process does not emanate from a central controlling authority, but is influenced by a large number of different actors and by numerous socio-economic and technical factors (Braun & Giraud, 2003).
From this perspective, governance processes do not emanate from the government alone, but represent the result of a governance process that arise from the interaction of all the actors involved from politics, the private sector and civil society. Thus, although the governance action of the state is a social sub-process, that interferes with many other sub-processes. However, in the diffusion of new technologies like electric mobility, electrical charging or 5G, the governmental control instruments are of decisive importance.
Without them, no universally accepted negotiation systems and balancing mechanisms can be created to manage conflicts that arise. On the other hand, the diffusion of innovations "depends to a considerable extent on the introduction and design of environmental policy instruments, since the intensity of market signals for environmental innovations often does not correspond to their economically desired significance" (Braun et al., 2019, p. 148).
The political challenge is that there are often a number of competing technical options, whose long-term development potentials are fraught with uncertainty. The decision in favour of a technology and the implementation of corresponding funding instruments is often associated with high investments in market development and the establishment of infrastructures. A too early commitment for an ultimately inferior technology is consequently associated with the massive misallocation of resources (Fox et al. 2017, p. 145).
Concerning mobility, the scientific and public debate on the most promising propulsion technologies of the future has been characterized by a series of cycles of attention over the last 25 years (Fox et al., 2017). Governments also often followed these cycles in their research funding, preventing a sustainable technological learning process (DIB, 2019). Overall, the uncertainty led to a certain paralysis of the sector. Against this backdrop, a targeted promotion of transformation processes eventually requires a political vision for the future mobility as well as planning and investment security through governmental long-term goals and corresponding political measures (DIB, 2019). This is even further confirmed, as the global debate on the future of mobility has also gained momentum in recent years.
At the same time, there is a need for regular review of the path taken and for readjustment if the expectations attached are proved to be wrong.

But in the area of drive technologies, it now seems clear that the combustion engine does not represent a sustainable option for decarbonisation, especially in the passenger car segment, due to its low well-to-wheel efficiency (Fox et al., 2017).

In order to lead electric mobility out of its niche, the federal government's funding programs must be continued and expanded. How long and to what extent government support for the development and expansion of the charging infrastructure will be necessary cannot yet be precisely estimated. It is also possible that the economic viability threshold for the provision of charging infrastructure will not be reached in all regions at the same time, for example due to different settlement densities (Gassmann et al., 2018). This may lead to a spatially differentiated funding approach in order to ensure sufficient infrastructure. Also in view of these uncertainties, a regular re-evaluation of the funding strategy is necessary.

Eventually, business models for the development and marketing of charging stations are as well becoming a critical factor in success. The acquisition costs, including development and operating costs, are only amortized through significant capacity utilization that of course, does not exist today. For this reason, it is not yet worthwhile for energy supply companies to invest on a larger scale. However, this could change if the costs incurred could e.g., be transferred to the grid fees or are taken on by other public systems. Then the currently reactive expansion of the charging infrastructure would become a real driver of electric mobility (PWC, 2018).
In order to overcome this chicken-egg-problem, several initiatives have therefore to be launched or to be continued with mutual support from industry, science and politics. One of the related measures is the development of a hydrogen infrastructure via the foundation of the joint venture H2-MOBILITY Deutschland GmbH & Co KG. The shareholders are Air Liquide, Daimler, Linde, OMV, Shell and Total. Initiatives, such as the H2-MOBILITY, have made it their task to enable the transition to a hydrogen-friendly Germany (DLR & ARAL AG, 2019). The aim of this project is to develop a comprehensive hydrogen infrastructure by 2023. This German hydrogen project has already decided on the question as to whether a chicken or an egg should exist first: regardless of how many hydrogen-powered cars are built, it wants to build 100 additional H2-filling stations in Germany by the end of 2021. The Shell hydrogen study, which recently published - "Energy of the future? Sustainability and mobility through fuel cells and H2" answers this question in the same way (cited in DLR & ARAL AG, 2019).
Nowadays various charging systems are being researched, for instance new Power-2-Gas charging concepts (Proff, 2015). In order to implement them, it would be necessary to set up and improve electrolysis plants to achieve low system costs in parallel. This cost reduction will hopefully then enable a mass market to develop, in order to assume that between 2021 and 2030 a commercialization of hydrogen will take place (Proff, 2015).

This problem is common to all new technologies and the key to overcoming it, is to subsidize value to early users. The example of electric mobility shows that a lack of infrastructure hinders the breakthrough of the technology and therefore purchase price incentives hardly have any effect. Innovations on one side (e.g. in vehicles) therefore always require simultaneous investments and innovations in the other area (in infrastructure). As described earlier, governmental intervention and cross-sector collaboration is required.

Against this background, the present thesis examines in particular questions that arise with regard to the provision of public charging infrastructure, the achievement of a sustainable business model, the new role of the mobility station and future mobility trends. It is not the focus of this thesis to provide exact figures, but rather to develop a framework with certain premises and estimations for public charging, based on robust data sources and assumptions. Please see the introduction and description of the overall research aim with key objectives in chapter 1.
In order to address the main research question and to define parameters and key criteria for an optimised business model with regards to related charging hubs, this research project will consider existing business model concepts in the overall market and will enrich them via available benchmarking aspects (Kunz, 2016). This also takes into account business models from other industries and illustrates the few available approaches for charging infrastructure. Premises and advantages of successful service concepts are incorporated and are an important basis for the research project. This also shapes the aim to consider the topic of business model innovation as a sustainable approach for public charging infrastructure (Wainstein et al, 2016).
This research led to the empirical evidence that a sustainability focus can result in a profitable charging business model. However, this research is not only investigating a positive relationship between economic success factors and sustainable business models. The research is also demonstrating new business opportunities evolving in the field of electrical charging and mobility services, which would have remained invisible in a purely profit-oriented approach. Accordingly, the contribution builds upon business model perception and application unifying different sustainability dimensions and transferring the consolidated findings onto a conceptual levelling that facilitates more all-embracing interpretations.

The nationwide establishment of a charging infrastructure for electric vehicles is a core requirement to ensure the overall market penetration of electric mobility. The focus here is on a practical and demand-oriented expansion of the public charging infrastructure; additionally some strategic decision criteria are to be considered. Based on the presentations and analyses of the previous section, it can be stated that the development of a publicly accessible charging infrastructure network appears necessary for a substantial substitution of fossil fuels and an overall decarbonisation, also assuming that potential users consider the electric mobility system as a viable alternative in the choice of modalities. However, this alternative to conventional vehicles only exists, if the quality of services and costs are similar to the traditional combustion engine vehicles.

CHAPTER 3 | LITERATURE REVIEW, BUSINESS MODEL THEORY AND SUSTAINABLE BUSINESS MODELS FOR THE FUTURE-CHARGING-HUB

In the previous chapter, different design options and characteristics of public charging infrastructure were presented. This is the groundwork for the following critical explanation of the overall need for public charging infrastructure and sustainable business models. Hereinafter, the basics regarding the usage and the users of charging infrastructure are shown. Charging hubs are classified as a part of the mobility system and the system specifics relevant to mobility are outlined below. The sustainability definition is crucial, as is the importance of filtering out various attitudes towards sustainable business modelling.

3.1 Theoretical underpinnings and framework

3.1.1 Selection of research environment and rationales for the choice of literature

A brief overview about the research environment and the rationales for the choice of literature can be found in the following. In order to achieve an enhanced readability at the very beginning, this chart is summarizing the first considerations (figure 9). This section is also a further guidance to the overall topic

Figure 9 | Research environment & stakeholder overview electric mobility and charging (Plankenauer, 2012, p. 23ff)

- According to the developments described above, electric mobility and the related charging infrastructure have a variety of stakeholders in different areas of interest.
- In respect of Plankenauer there is also an illustration of the market segments and the business environment (Plankenauer, 2012), the research-relevant segments are “electric vehicles” and “charging and energy”.

government | politics & society

market participants	technology-companies		service providers
business environment and market segments	**electric vehicles** • car manufacturers • suppliers • car-sharing and fleet companies • public transport companies	**charging & energy** • utilities • network operators • equipment manufacturers of charging technology • service operators	**batteries, hydrogen technology** • manufacturers • recycling companies **car-2-X-communications** • IT-based service companies

users & customers

research institutes

To carry out a detailed evaluation of charging stations the overall stakeholder analysis mentioned above, is extremely important. This first stakeholder view shows that due to electric mobility and the clear need for a broad public charging infrastructure new participants are entering the market, and there is a call for new business models (Plankenauer, 2012; Toshiba Corporation, 2017). This stakeholder outline is also crucial for refining the literature review. Based on that, the literature research is focusing on "charging and energy" and in this context with clear emphasis on "service operators and their business models". This stakeholder analysis has made literature research extremely effective, because there is a great variety of new literature in this emerging field of research and it is all the more important to set clear priorities.

Most actors are facing major challenges in planning and building charging infrastructures.
Potential operators of charging points currently do not see any positive economic outcome (BCG | Young & Reeves, 2020). Despite some risks and various possibilities for technical focus in future, this represents as well a significant embedded chance to generate profits (Deloitte, 2020). Nevertheless, it is hoped that the charging infrastructure will open up completely new and innovative business models for different business partners (Deloitte, 2020). As mentioned, closely linked to this technology turnaround towards electric mobility, there are several decision factors to be evaluated (Deloitte, 2020). These main issues (figure 10) will be reflected in general as the first pillars of a concrete business model definition related to a public charging station (Deloitte, 2020).

Figure 10 | First pillars of a concrete business model (Deloitte, 2020)

- Business model: basic business model or integrating additional services
- Value chain position: providing charging infrastructure, e-mobility services and full service provider up to the supply of electric cars as e-mobility provider
- Related technical solutions: normal charging- and fast charging points or hydrogen charging facilities
- Operating model: outsourcing or own operation, maintenance and service
- Customer access model: public access or privileged e-mobility | charging infrastructure as a business area, access for limited customers
- Price model: price for period | e. g. kWh or usage fee, pricing in connection with other products
- Invoicing services and user management: insourcing, cooperation or outsourcing

In the scientific literature, new forms of business models about electric mobility are discussed and different definitions of "a service-based business model" are available. This could be summarized briefly, that via a service business model a company generally tries to determine how it can configure its resources and competencies to address the service-value of the end-customer (Fornahl & Hülsmann, 2016, p. 1-48).

This offered scope of services has to be defined in advance and taking the decision as to whether only charging infrastructure and power supply should be provided, or if value-added-services are also going to be integrated, e. g. electric leasing cars and fleet management concepts, invoicing services, shopping or repair services, etc. (Deloitte, 2020).
Referring to this, service strategies will also enable additional value proposition for the end-customer so that the diffusion of electric mobility and charging infrastructure are supported and as described by Fornahl & Hülsmann, the risk of market failure can be reduced (Fornahl & Hülsmann, 2016, p. 28). Against this background, reference is also made once again to previous explanations of market failure, e.g. according to Janssen et al. (2006).

Markkula and colleagues (2013) clearly state, that an existing business model could be described very easily, but validating new ones is more challenging. New business models are defined on the basis of hypothesis and assumptions regarding how things are or will be. However, the most important variable is the customer – without a paying customer there is no viable business (Markkula, et al., 2013).
Such a business model describes how a company operates, but there is no generally accepted definition available. The various explanations for a business model should help to understand the key factors of corporate success (Teece, 2010).
Colmorn and Hülsmann argued, that it is still not clear, which of the newly arising business model concepts is the most promising one for electric mobility charging, or in which way existing business models should be adapted in parallel. With respect to an applied service strategy, the majority of the German companies are very well positioned. It is also shown in several studies by Colmorn & Hülsmann (2018), that in particular potential exists with regard to the development of new electric mobility-services. The interconnection of a company's service portfolio is of high importance, so that each additional service increases the economies of scope for the customer (Colmorn & Hülsmann, 2018). These considerations are clearly based on the assumption that the technology of electric mobility does not focus on the ownership of a special product any longer; instead of this offering, a mobility service becomes vital (Fornahl & Hülsmann, 2016).

3.1.2 Discussion of relevant academic disciplines and theoretical underpinnings

“General strategy, corporate strategy and competitive strategy” concerning electric mobility and charging infrastructure, are the main academic disciplines chosen for this thesis. Overall, the reason for this is primarily the intended focus on new business concepts and their commercial design. Corporate strategy defines the vision, the markets and the businesses in which an enterprise operates. Strategy, in general, refers to how a given business target will be achieved and necessary resources are structured and allocated (Schumpeter, 1947; Freeman, 1984; Götze & Rehme, 2011). Competitive strategy defines for a given business the basis on which it will compete, the company's strengths and weaknesses in relation to market characteristics and the corresponding capabilities of its competitors (Götze & Rehme, 2011). Please see related Venn-diagram (figure 11), visualizing this strategy definition.

Figure 11 | Venn-diagram “strategy” (Götze & Rehme, 2011, p. 13)

Against this background, important theoretical underpinnings for this research project are in parallel hybrid competitive strategies. These approaches have been defined, for instance by Gilbert and Strebel (1987). Hybrid competitive strategies alternate between two positions, but consistently pursue only one of the two alternatives within a given time span. First, they gain competitive advantage in one of the positions, and then endeavour to catch up with their competitors and switch to the other direction. For instance, a company can first apply a differentiation approach via launching technical innovative products and achieving high prices. After a certain time imitators inevitably appear on the scene and have to be pushed back by changing the strategy to cost leadership. Such an approach is called outpacing or overtaking strategy. It is mostly used in case of major strategic changes in the sales markets (Sonnenschein, 2001).

Because this thesis will develop new business models for new charging technologies, this research approach pursues a related strategy to win market share and enable sustainable market penetration. This approach in the electric mobility sector calls for products or service packages, which are perceived, industry-wide, as being unique. Electric mobility- and charging solution companies aim to be unique in their industry along certain dimensions, which are widely valued by customers. Selecting one or more attributes that many buyers in these sectors perceive as important, uniquely positions it to meet those needs, and it is optionally rewarded for its uniqueness with a premium price (Winkler & Slamanig, 2009); for instance, when fast charging services are taken into account.

From there another theoretical underpinning is the “5 P’s of Strategy Model”, which was developed by the management expert Henry Mintzberg with the target to develop five distinguished strategic visions for the organisations (Winkler & Slamanig, 2009). The five strategic visions are “Plan, Pattern, Position, Perspective, and Ploy”. All the five directions allow the organisations to implement the strategy in a more effective manner (Winkler & Slamanig, 2009).

Besides, highly relevant underpinnings are Porter´s “Five Forces” and his “generic strategies”.

Porter´s “Five Forces” can be considered as independent approaches to strategy and as different viewpoints or perspectives, which should be implied, when developing strategy (Winkler & Slamanig, 2009; Porter, 2014). The “Five Forces” are shaping the understanding for the competitiveness of a business environment and the identification of the strategy`s potential profitability. By understanding, the driving forces related to a certain business environment, the strategy could be adapted accordingly, when profitability is affected. This leads to clear insights for the strengths and weaknesses and the impact on long-term profitability.

The most important statement of Porter's model of generic strategies, which is also still valid today, is that every company should have a clear vision of what special advantages it wants to offer to its customers in order to maintain a strong market and competitive position. These can be price advantages, a special image, additional services and many more, as well as various combinations of these. Questions of positioning and the definition of target groups must also be included. Thus, two decisive questions can be derived from Porter's model, which are likely to be relatively timeless from a strategic- as well as marketing point of view (Porter, 2014, p. 58):

- “Who are my customers?
- What do I offer my customers so that they choose my product / service among all the competing offers?” (Porter, 2014, p. 58).

Hamel and Prahalad present a further developed entrepreneurial concept (1994). According to this approach, the aim for future competitiveness has to be integrated into the corporate strategy in order to respond to the need for adaptation with the highest degree of flexibility. The authors provide valuable proposals to develop their own competitive strategy by questioning and reorienting business practice (Hamel & Prahalad, 1994). In addition to Mintzberg and Porter, these authors assure valuable proposals for the development of a competitive strategy, besides questioning and reorienting business practice (Winkler & Slamanig, 2009).

The main theoretical basis could finally be supplemented with the approach of Aloys Gälweiler (Gälweiler, 2005, p. 84ff). From Gälweiler’s navigation model, the key value “innovation” can be derived (Gälweiler, 2005). Gälweiler describes the aim of strategic management as "to secure the long term ability of survival and the future potential of success" (Gälweiler, 2005). Innovation management and its models can be regarded as established procedures, methods and processes in science and corporate management (Disselkamp, 2005, p. 32). The term innovation management refers to a "systematic planning, management and control of transferring ideas into innovations in scope of an organisation" (Schuh, 2012, p. 17).

Innovations are essential for the success of a business model and therefore Hamel (1998) ascribes the importance to an innovation or the way or the possibility to develop innovations in a company as “being a most important business issue”.

It is of central importance to maintain a fundamental understanding of innovation, which means the "generation, development, and adaption of an idea or behaviour, new to the adopting organisation" (Damanpour, 1996, p. 694ff) and thus leads to changes in the organisation and appears as the "first successful application of a product or service" (Cumming, 1998, p. 21ff). The innovative path can be taken radically or systematically, so that innovation can be seen as a key factor for the sustainable survival and success of a company (Tidd, Bessant & Pavitt, 2001). It is often not clear whether innovations are the result of a business model or vice versa (Chesbrough, 2007, pp. 354-363). The business model must not be exclusively focused; according to the authors Müller & Thoring, this often leads to the failure of innovations (Müller & Thoring, 2012, p. 156). Geissdoerfer et al. (2018, p. 401) is in parallel highlighting, “that the capability to rapidly and successfully move into new business models, is an important source of sustainable competitive advantage and a key leverage to improve sustainability performance of organisations”. Thus, developing an innovation strategy should start with a clear understanding of specific objectives related to helping the company achieve a sustainable competitive advantage (Girotra & Netessine, 2013).

A competitive advantage for a company is created by entrepreneurial and strategic activities. These can be factors such as price structuring, special characteristics of sales or flexible production models (Johansson & Woodilla, 2009). But competitive advantages can also arise in special market niches. A sustainable competitive advantage is a competitive advantage that can be maintained over a long period, as opposed to one that results from a short-term, tactical support measure (Johansson & Woodilla, 2009). Unless innovation induces potential customers to pay more, saves them money, or provides some larger societal benefit, namely improved mobility or charging, it is not creating value (Drucker, 1994). Certainly, technological innovation is a huge creator of economic value and a driver of competitive advantage according to Porter (Porter, 1980). However, some important innovations may have little to do with new technology. In the past couple of decades, several companies (Netflix, Amazon, LinkedIn) have mastered the art of business model innovation. Thus, in thinking about innovation opportunities, companies have a choice about how much of their efforts focus on technological innovation and how much they invest in business model innovation. Innovation should be characterized along two dimensions: the degree to which a change in technology is involved and the degree to which a change in business model it involves (Grobman, 2005; Kim & Mauborgne, 2005).

One example for changing the business model, are cross-regional charging solutions (Kim & Mauborgne, 2005). These have gradually gained acceptance. In order to avoid entering into charging contracts with every regional provider, roaming providers are being established – similar to the mobile phone industry. These providers bundle access and billing for different charging stations across Europe. Nowadays, the choice could be from a number of providers (e.g. “VW Charge & Fuel Card”). Many of the ~ 100,000 charging stations in Europe already allow charging – with great economic success and independently of the provider (VW, 2019).

So far, the research environment and the main stakeholders have been defined. The object of investigation is located in the business segment “charging and energy”. Initial ideas derived from literature are the main pillars of a business model decision. This is followed by the main theoretical underpinnings and a clear link to business management, corporate strategy and innovation. There is no doubt that electric mobility is an essential part of the mobility mix of the future. However, in order to evolve from today's niche existence to a central driver of individual mobility, sustainable changes are also required. This shapes the need for business model innovations in terms of electric mobility and charging. In terms of business model theory, further details are described in the following chapter 3.2.

3.2 Business model theory and sustainability

3.2.1 Analysis of business model theory

The core logic of a business activity is summarised under the term “business model” (Karlusch et al., 2018). The literature, however, presents various perspectives on the global business model concept. The overall definition is a representation of the value logic of a company and how customer values are created and captured. While most authors are not very explicit about what they in fact mean with value, most definitions seem to refer to customer value (Afuah, 2003; Osterwalder & Pigneur, 2010). Thus, the business model concept is partially criticized for being vague and lacking consensus on its definition and compositional elements (Zott et al., 2011). The various definitions evolved, are summarized as following (figure 12).

Figure 12 | Analysis of business model theory and related definitions (own summary)

Lewis (1999) Lewis, 1999, p. 33ff; Johnson, 2008; Karlusch et al., 2018	• Connected business model concept with e-business • Theory as “term of art” with similarities, because for both a real definition is quite difficult, as it depends on how it is used
Porter (2001) Porter, 2001, p. 71	• Incorporates strategy related definition • “How all the elements of what a company does fit together” • Premises are also about identifying customers and competitors; their values and also their market-based behaviours
Casadesus-Masanell and Ricart (2010) Bowman & Ambrosini & 2003; Cited in Johnson, 2008, p. 204	• “Reflections of realized strategy” • Described, as a system, how the pieces of a business fit together • Strategy shapes the development of capabilities that can alter current business models in the future • Strategy is much more about building dynamic capabilities aimed at responding efficiently to future and existing contingencies
Chesbrough (2007) Chesbrough, 2007, p. 354ff; Slávik & Bednár, 2014	• “A useful and functional framework to link ideas and technologies to economic outcomes”
Magretta Cited in Johnson, 2008, p. 54; Cited in Karlusch et al., 2018	• “At heart, stories explaining how enterprises work” • “Contains precisely delineated characters, plausible motivations and a plot that turns on an insight about value” • It also answers Drucker’s age-old questions: Who is the customer? Besides, what does the customer value and pay for?
Slávik and Bednár (2014) Slávik and Bednár, 2014	• Shifted from this context to a much broader perspective, while also defining how a business is conducted in general
Joyce and Paquin (2016) Joyce and Paquin, 2016	• The definition gives information about the alignment of high-level strategies and underlying actions, to support strategic competitiveness
Grassmann et al. (2017) Grassmann et al., 2017, p. 1	• No unified definition for major components in science • Defined as “how the magic of a business works, based on its individual bits and pieces”

Drucker Karlusch et al., 2018	• Developed a “theory of the business model” • “Assumptions about what a company is paid for” • Integrates market-based premises
Karlusch (2018) Karlusch et al., 2018	• An enterprise puts the strategy into action through the design of the business model, which denotes and organises its activities

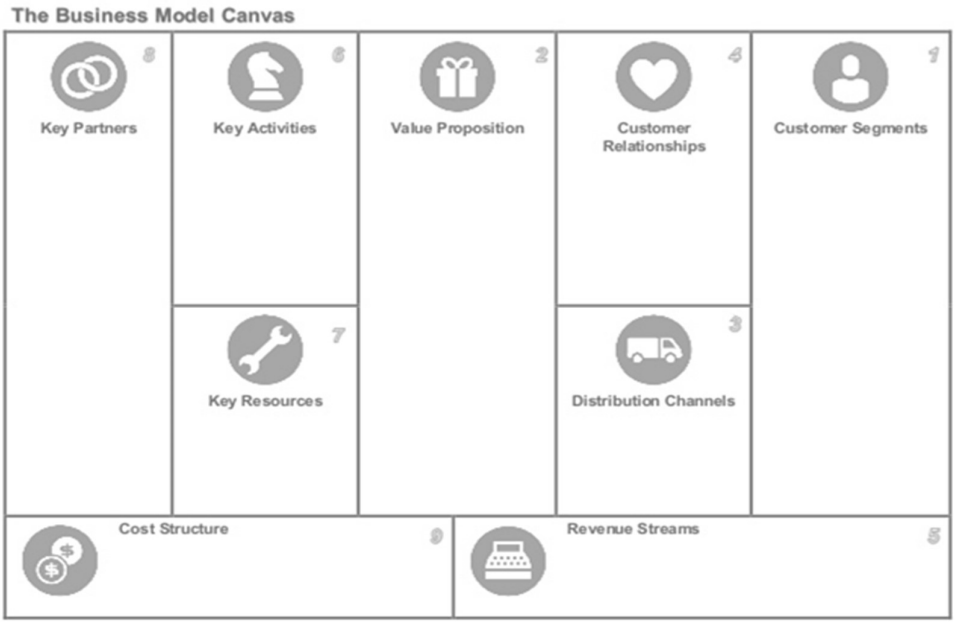
A newly emerging business model may offer an improved value to a discrete group of customers and may therefore completely replace the old way of doing things. Creating a business model is then, “a lot like writing a completely new story” (Johnson, 2008, p. 54). In addition, when a new model changes the economics of an industry and is difficult to replicate, it can by itself create a strong competitive advantage (Proff, 2015).

Nonetheless, business model logic is rarely addressed in research. This is really unexpected, for instance, due to a BCG-study (2020), which proved that business model innovators were more profitable by an average of 6% compared to pure product- or process innovators (Grassmann et al., 2017). As a consequence, business model innovation is often considered to be more important for achieving competitive advantage than product- or service innovation.
Further details about business model innovations and sustainable business models are summarized in the chapters below | 3.2.2. and 3.2.3.

3.2.2 The new strategic perspective of business model innovations and service solutions

According to Osterwalder and Pigneur, “a business model describes the rationale of how an organisation creates, delivers and captures value” (Osterwalder & Pigneur, 2010, p.14). With reference to Osterwalder and Pigneur (Osterwalder & Pigneur, 2010) a business model can be described as a set of assumptions. Therefore they invented the “the business model Canvas”, which is a tool for developing innovative business models (Keane et al., 2018). It consists of nine business model building blocks, which Osterwalder and Pigneur argue can be used as a structured procedure for defining key premises related to cutting-edge business models; e.g., key premises are resources and activities, value proposition, customer relationships, channels, customer segments, cost structures, and revenue streams (figure 13) (Osterwalder & Pigneur, 2010).

Figure 13 | The business model Canvas (Osterwalder & Pigneur, 2010, p. 24)



The Canvas business model identifies the essential parts of a business; its practicality and simplicity has led to broad acceptance and extensive usage (Toro-Jarrín, 2016). There are also some variations of the business model Canvas. For instance, to emphasize a service-dominant logic, this could be easily applied in practice. Such a business model should enable service innovation solely based on customer value, meaning customer centricity as main focus of all the elements of a service-business model (Ojasalo & Ojasalo, 2018). Besides an advanced service-orientation, there are other current developments, that can be integrated in such a business model as Canvas. For example the “sharing economy”, which is one of the most important building blocks in the transition towards sustainability. A sharing economy business model could also be reviewed by the Canvas-approach and could clearly be linked to the business model literature (Ritter & Schanz, 2019). Another Canvas-variant could illustrate the new company’s sustainable value proposition, considering all three pillars of sustainability: environment, economy, and society (García-Muiña, et al, 2020).

Pigneur, Paquin and Upward added two new dimensions to the Business Model Canvas - a social and an ecological one. This is because a good business model assures improvements for all stakeholders - including customers, partners and the environment, across the entire value chain (Paquin, et al., 2016). Instead of merely adding indicators to the "bottom line" and thus only looking at the result, they developed two new Canvases that operate according to the same logic as the Business Model Canvas. The “Environmental Life Cycle Business Model Canvas” and the “Social Stakeholder Business Model Canvas” include further levels of the value creation process, whose consideration appears to be just as important as its economic significance. Interestingly, it can be used not only to check a business model for its sustainability, but also to develop a system that can be used to generate sustainable ideas for innovations (Ritter & Schanz, 2019).

The Canvas-approach undoubtedly makes important contributions to integrating and structuring the diverse understandings of the business model concept. So it basically provides a platform to present business models in a simple and illustrative way. The in-depth view of a company's business dynamics opens up the field for discussion and creativity. However, with regard to the process of business model development, it remains incomplete. Notably, some aspects can be criticized here (Schallmo, 2013; García-Muiña, et al, 2020).
The Canvas does not fully consider competition and contextual factors such as laws, trends or industry development. Thus, the business model Canvas remains a model focused on the customer and the inside of the company without considering the external world. Complementary approaches such as the PESTEL-framework or the Five Forces-model (see 3.1.2) are much better suited for this purpose. Also not in the scope of the Canvas are strategic aspects such as the overall company vision or targets. A business model Canvas only considers the business model at a discrete point in time. For each intermediate step towards a new business model, a separate Canvas must be created or a roadmap has to be developed (Grassmann et al., 2017). Finally, Canvas does not provide concrete guidance on the development of products or services. The focus is on a rather generic business model.

An alternative approach here is the St. Gallen Business Model Navigator (Grassmann et al., 2017).
Throughout Grassmanns` studies, a business model is described via a conceptualization with four dimensions: the “Who”, the “What”, the “How” and the “Value” (Grassmann et al., 2017).
Via this alternative approach (Osterwalder & Pigneur, 2010); a clear picture of the business model architecture could be achieved (Grassmann et al., 2017). This model structures the process of innovation of a company’s business model and motivates to outside-the-box thinking, namely encouraging very creative ideas as key prerequisite is the basis for deriving successful business models (Grassmann et al., 2017).
According to Grassmann, in the future, “competition will take place between business models and not just between products and technologies” (Grassmann et al., 2017, p. 2ff). Within this context, the greatest attention nowadays is focused on the innovation perspective of business models.
But also concerning Grassmann`s viewpoint there are some optimisation points. One major aspect is that the organisational embedding is not entirely defined; for instance, which roles or persons should be involved.

There are only corresponding references to address employees, to define structures and to implement a change towards the new business model. However, these considerations are not directly integrated in the theoretical process model (Rommerskirchen, 2019). Besides the existing framework is generic and does not have an industry-specific focus. This is partly justified by the fact that business model development-projects are always unique and an independent approach is therefore preferable. Grassmann`s model was mainly developed together with stakeholder companies from mechanical engineering, telecommunications, software, energy, and financial services.
Since customer needs are usually seen as the most important starting point for business model innovation, it is obvious to involve customers in this process in the sense of "open innovation". Other external partners can also contribute to product- and business model innovation with their special skills and knowledge. However, the integration of external partners is more difficult in business model innovation than in product development. Accordingly, the integration of customers and partners is an emerging trend, but not yet a lived practice in Grassmann`s business model development (Rommerskirchen, 2019).

Nielsen & Lund (2015) point out, that tools such as the business model Canvas are extremely helpful in overcoming the barriers that protect the extant business model. New business models dynamics regarding electric mobility are convincing companies to question their current business cases and to strive for business model innovations (Nielsen & Lund, 2015).
A business model design, via Canvas, fully supports the development of a more holistic and integrated view of a business model. This also promotes creatively innovating towards more sustainable business models (Joyce & Paquin, 2016). Referencing to Schaltegger et al. (2016), scholars agree that, “the business model is not only a facilitator of technological and organisational innovations. It can become, subject to strategic innovation itself in order to share and leverage resources such as knowledge, managerial- and entrepreneurial skills, or to facilitate reconfigurations of the underlying value chain or value network” (Schaltegger et al., 2016, p. 108). Finally, it is also very important to bear in mind that Business Model Canvas and Design Thinking are not new; these approaches have evolved over time.
According to Afuah: “A business model is the set of activities which a company performs, how it performs them and when it performs them as it uses its re-sources to perform activities, given its industry, to create superior customer value and put itself in a position to appropriate the value” (Afuah, 2003, p. 16ff). Against this background, Afuah, (2003) associates electric mobility with new and innovative business models. These models focus on compensation for the existing technical disadvantages of an electric vehicle by changing the conventional business model. Another aspect leading to a new business model is to create an additional value added for the customers concerning electric mobility and thus, e.g. an optimal public charging approach.

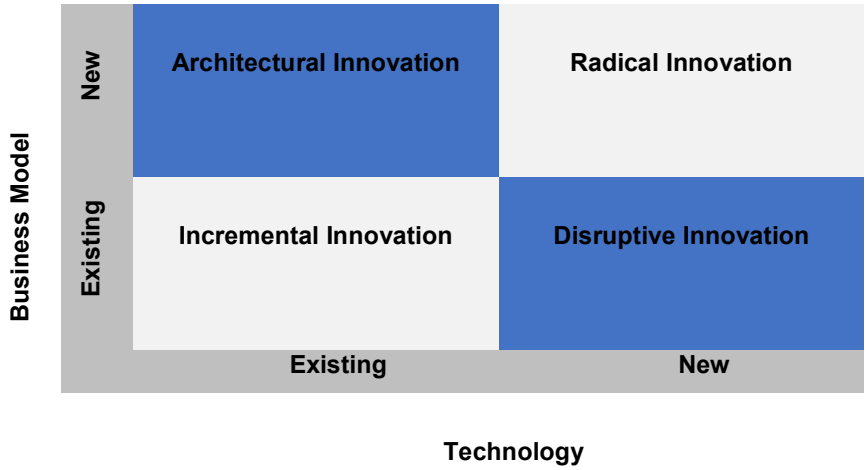
Pisano clearly posits the following question: “What types of innovations will allow the company to create and capture value and what resources should each type receive” (Pisano, 2015, p. 9). Pisano goes on to highlight that it is of high importance to choose what kind of value an innovation creates. This is a fundamental decision, sticking to it is critical because the required capabilities for each are quite different (Pisano, 2015).

Pisano appreciates technological innovation and its high contribution to economic success. From this author's point of view, technology is a main driver of competitive advantage, but in parallel, some key innovations mentioned are not related to new technology at all. In recent years, several companies with major business model innovations such as Netflix, Amazon, LinkedIn, Uber have evolved. Thus, when thinking about innovation opportunities, the decision has to made about how much of the possible efforts should be focused on technological innovation and how much to invest in business model innovation (figure 14).

Just as sustainability and environmental issues are rapidly emerging as one of the most important topics. This new awareness also has to be reflected in scope of innovative and environmentally conscious products and services or new business model innovations. The sustainability definition according to Hart and Milstein considers the needs of the present generations "without compromising the ability of meeting also the needs of future generations" (Hart & Milestein, 2003). Eco-innovation has become one of the important strategic tools to obtain sustainable developments and assure profitable growth (Pisano, 2015).

A company's innovation strategy should specify how the different types of innovation fit into the business strategy and the resources that should be allocated to each (Pisano, 2015). Several researchers are exploring how business models could be changed and organisations can be converted to new ones. However, only a few studies quantitatively analyse business model performance and compare performance values. Future work should be aimed at analysing and understanding the relationship between innovative business model architecture and performance much more (Böhm et al., 2017). In the following diagram, the classification model described by Henderson and Clark (1990) is used with regards to the basic business model theory and innovation (figure 14).

Figure 14 | Classification model describing innovations (Henderson & Clark, 1990, p. 9-30)



In this model, there are two factors involved in the innovation process: technology and business models. In one dimension, the technology involved might change or advance. The other dimension relates to changes in the business models. If innovation happens across both dimensions in small steps, we have "incremental innovation" (Henderson & Clark, 1990). If technology alone advances significantly, "disruptive innovation" is the result.

Thus, when introducing completely new business models into existing markets, this is a so called “architectural business model innovation” (Christensen, 1993; Pisano, 2015). This also means that disrupting the business model with existing but quite new technology leads to “architectural innovation”. In addition, when in parallel the two dimensions are enriched, this leads to “radical innovation”; a “radical innovation” is the counterpart of a “disruptive innovation” (Henderson & Clark, 1990), where the challenge is purely technological.

The emergence of the digital photography is an example of combining technological aspects and business model innovations (architectural innovation). For instance for Kodak and Polaroid, digital world resulted in coping with completely new competences in solid-state electronics, camera design, software, and display technology. Nevertheless, it particularly meant finding a way to achieve business success based on cameras rather than “disposables” (Howells, 2005). This means that the development towards digital photography also resulted in a completely changed architecture of the product. Cameras were no longer a stand-alone product. They became a part of the telephones and methods of sharing, printing and in fact using photos completely changed (Howells, 2005). Despite Kodak’s technological digital breakthrough, simultaneous with its competitors, the company was unable to adapt to new emerging business models.

Radical innovation is challenging, but it is also visible. The necessity for business model innovations is often underestimated and it is the reason why companies fail, as Kodak did. It often seems to be only a small change related to one single part of the overall puzzle, but it is actually about a complete rethink of the ways the pieces are merged and fit together (Naughton, 2002). Therefore, architectural innovations are most challenging. A corporate innovation strategy should in general imply a matching of the various types of innovation into the business strategy. In much of the literature on innovation today, radical, disruptive, and architectural innovations are viewed as the keys to growth (Naughton, 2002).

Besides the authors, Giotra and Netessine (2013) dealt intensively with changes in existing business models and developed a four-step model towards a new business model innovation: changing the mix of products or services, postponing decisions, changing the people who make the decisions and changing incentives in the value chain (cited in Naughton, 2002). Finally, in his book “Reinventing Your Business Model”, Mark Johnson (2008) presents various new business model approaches, e.g. the so called “pay as you go”- or “energy as a service”-concept, which also means electrical charging for actual metered usage. The particularly advanced way of combining product and product-related services is the operator model, in which industrial companies provide technical solutions e. g. charging infrastructure, then operate the charging station themselves and are paid according to its output – within a new concept of “energy as a service” or “pay per use”. Eventually, the firms can try to develop their innovative products into complete problem-solving packages for their customers (Bullinger, 2004).

This is also the overall intention in scope of this research project, redesigning the charging business model by integrating multi-modal mobility service offerings. Via this architectural innovation approach, a successful and sustainable business model should be achieved. Architectural innovations are creating a novel "architecture" of the complete sector of electric mobility and electrical charging. This is in the

form of new production and marketing organisations and new product- and -service characteristics that will undoubtedly have a long-lasting impact.

Grassmann clearly emphasizes, that companies have to maintain their capabilities of innovative strengths (Grassmann et al., 2017). New business models are often based on so called “early weak signals”; trendsetter signals, totally new customer requirements or new regulations, broadly discussed before they are eventually approved (Grassmann et al., 2017).

At the beginning of the 1990s, “services” might only be linked to academic literature. However, nowadays a growing number of industrial companies are proactively integrating services to increase the attractiveness of their present range and improve their business model. The target is to become more competitive, create more added value and open up new markets (Bullinger, 2004). The way in which enterprises provide services to their customers is completely changing. In this regard one of the major influences is the current sustainability development (see following chapter 3.2.3). Sustainability is causing changed behaviours, preferences and attitudes on both sides – on the supply – and the demand side. In this sense, sustainable business model innovations are meant to profoundly change the way business is done and services are offered via emerging new revenue streams and value propositions related to sustainability. However, in many companies a high uncertainty currently exists about requirements for a successful development of new services. Only a few companies have established a separate services development as a systematic approach for efficient planning, design and marketing of new services. The development goes from the pure product to a problem-solving approach. This potential is still far from fully exploited (Bullinger, 2004). According to key literature sources and related debates, the importance of service-based business model innovations is also increasing in the electric mobility business (Naughton, 2002). Due to the specific market conditions, charging service providers have to use the possibilities arising by new mobility trends and behaviours. In the medium-term, focus is on the achievement of sustainable service business models, to enable the transition towards electric mobility and related public charging.

3.2.3 Sustainable business models

Drucker (1994) who asked key questions defined the term business model in its main features: “Who is the customer?” “What does he value?” and “How can you make money from it?”. As mentioned before, the new concept of the “business model” has its origins in the Internet business and it has been discussed in many different ways in the context of strategy development, innovation, etc.

In the 1970s, the term business model was mainly used for business modelling, i.e. the description of business processes and information systems (Böhm et al., 2017). The concept initially served as an instrument to better understand also interactions within a company. As a result, the strategy aspect became increasingly important and the business model was used afterwards for the holistic description of entrepreneurial activities and was applied for management decisions. According to Zott and colleagues, the concept of the business model is based on central aspects of Porter's value chain, in particular on the basic idea that the company's activities and different value drivers (cost leadership and differentiation) are of high significance for the company's profit (Zott et al., 2011).

From there a business model is a simplified representation of a profit-oriented enterprise, consisting of the essential elements of the company and their interconnections (Hoppe & Kollmer, 2001). Slywotsky (1996, p. 4) describes “business model design as the entire system consisting of activities and relationships according to which benefits are provided to customers and how profits are generated for the company”. This definition largely corresponds to the classic purely profit-oriented understanding of the business model.
Furthermore, the business model is characterized by the theory of the resource-based view. Sustainable competitive advantages can be created based on valuable, rare, non-imitable resources and the company's ability to leverage these competencies. According to Hamel, it is often precisely the critical resources, which lie outside the company itself (Hamel, 1998). This circumstance makes a value network necessary, which supplements and strengthens the enterprise resources. Thus, the design of the network itself can be an important source of business model innovation. As a result, the business model concept was broadened in its conceptual understanding and perspectives such as change management and innovation were integrated. Schumpeter defines innovation as "doing of new things or doing of things that have already been done, but in a new way." In this definition, it becomes clear that innovation is not purely limited to products, but must be viewed more comprehensively. Business model innovations have the potential to break through the existing industry logic and establish sustainable corporate success.
In a more elaborated definition, according to Casadesus-Masanell and Ricart (2010, p. 197), “a business model refers to the logic of the firm, the way it operates and how it creates value for its stakeholders”. Instead, they use the term stakeholder, which goes beyond the customer. Consequently, stakeholders influence the success of the company. According to Casadesus-Masanell and Ricart (2010, p. 197), however, companies can also create value for external partners and society.

Thus for some time now, the traditional role of businesses has been changing and the only targets are no longer about maximizing profits and shareholder returns. Nowadays, this perspective is reversed due to an intensified environmental- and social awareness. In 2016, the United Nations enacted 17 Sustainable Development Goals (SDGs) as a common global agenda until the year 2030 (Wpn, 2020). These targets were agreed upon by 193 UN members and are therefore a major pillar of sustainability and international policy coordination. The SDGs thus have a direct impact on the design of innovative business models, as companies are enforced to ensure sustainability and creating shared value by putting specific environmental or social targets into practice. Especially related to this thesis and the research aims are the following SDGs (United Nations, 2020; Wpn, 2020):

- No. 7 | Affordable and clean energy
- No. 9 | Industry, innovation and infrastructure
- No. 11 | Sustainable cities and communities

These SDG are supporting an orientation for the organisational development towards a sustainable business model (Wpn, 2020). There is a broad conceptual variety of business models that can be built

around sustainability targets, thus creating new opportunities for sustainable mobility concepts (Arend, 2013; Eckhardt, 2013; Wpn, 2020).

This sustainability-oriented business model development requires early and systematic consideration of sustainability aspects. Sustainability-specific issues should be taken up during the development of individual business model elements. The "Value Mapping Tool" was developed by Bocken and colleagues. This is used to illuminate the benefit dimension of the business model from the different perspectives of the stakeholders involved (Bocken et al. 2014). In the simplified form of the tool, a distinction is made between four stakeholder groups: customers, network partners, the environment and society. With the rise of the internet and digital firms, this concept has even gained more attention in research and practice (Böhm et al., 2017).
Business model theory clearly has a long historical development in e-commerce and entrepreneurship. Business models that can be built around sustainability targets are creating new opportunities for competitive advantage and business model research (Eckhardt, 2013). The realization of the UN's global agenda 2030 requires not only the commitment of policy makers; in fact, the implementation of the SDGs requires action being taken at a company level.

However, related first business model approaches do not in any way address the complexity or the contexts that exist when companies independently address ecological- or social value creation goals beyond a profit- and revenue perspective. This sustainable attitude is very much influenced e.g. by international companies such as McDonald and the growing awareness that each purchase has ethical, resource, waste and community impact and -implications. When individuals consider the adoption of sustainable lifestyles, they engage with an increasingly complex decision-making process, influenced by practical-, environmental- or ethical concerns (Moisander, 2007, p. 404).
People today have enough consumables, thus they strive to move up Maslow's hierarchy of needs instead. This also results in the fact that global issues, namely climate collapse and decarbonisation attract such widespread interest (Hofmann, 2019). Berkers (2020, p.1f) indicates that a successful business model always "thrives under the forces of the market. It scales, replicates and lasts". Because of this, business models are of high importance for driving sustainability to the next levels. Such a business model should prioritise customer value and company profit in parallel to benefiting the environment and society. However, awareness of this is not always possible on a daily basis. Conventional business models have been brought to perfection over many years and suddenly enriching them with sustainability requirements is not an easy ambition. Berkers poses the question: "How to find the new magic formula to bring sustainability benefits, without sacrificing, or perhaps even enhancing customer value and company profit?" (Berkers, 2020, p.1f).
Interest in sustainable business models has grown rapidly and there is an expanding range of research in the field by various authors (Boons & Lüdeke-Freund, 2013; Bocken et al., 2014; Schaltegger et al., 2016). The importance of sustainability management in companies has been identified, discussed and it characterizes a new way of doing business via defining "business models for sustainability". Therefore, a debate is currently developing around the term "business models for sustainability", which aims to create a theoretical foundation, in addition to the analysis of practical empirical work or case studies.

John Elkington, the founder of a British consultancy called Sustain Ability (Slaper et al., 2011), first coined the related “triple bottom line” expression in 1994. The three layers “profit, people and planet” are defining this “triple bottom line” and are shaping multidimensional impacts of an organisation nowadays. Corporate sustainability is defining business performance economically, environmentally and stakeholder-related. Considering all these perspectives, sustainability aims at enhancing the quality of life in three fundamental dimensions: the economy, the environment and the society.

Boons and Lüdeke-Freund (2013), for example, develop a position in which they advocate a strong sustainability orientation in terms of business model innovations (Boons & Lüdeke-Freund, 2013). Digitization, especially, and the urgency to address environmental and social issues have led to the clear need for sustainable business model innovations. This evolving awareness for sustainable outcomes is heading for profits via delivering products and services that also benefit the environment. Enterprises are in general having huge effects on the environment or the social framework. Thus, it is an important prerequisite for a sustainable development and business success, which the most important parties concerned are comprehensively supporting (Lüdeke-Freund et al., 2018).

Still, it is indeed true that there is no automatic relationship between voluntary environmental activities and business success (Schaltegger, Lüdeke-Freund, & Hansen, 2016). Research on sustainable businesses shows that the full potential of enterprises to solve ecological, social, and economic problems requires more than new products or new organisational practices (Schaltegger, Lüdeke-Freund, & Hansen, 2016). There is a need to innovate the frameworks used to create, deliver, and capture value, i.e., business models that contribute to a sustainable development of the natural environment, society and economy (Lüdeke-Freund et. al, 2018). A robust and financially sustainable business model is, according to Ciesielska & Iskoujina (2018), successful in expanding into new markets and differentiating its products and services and in generating profits. In addition, a financially sustainable business should be scalable, i.e. increasing profits, resulting in lowering marginal costs (Ciesielska & Iskoujina, 2018). Today, sustainable business models are increasingly seen as a source of competitive advantage (Nidumolu et al., 2009; Porter and Kramer, 2011). In parallel noted by Erath (2014), that sustainable business models aim to gain a competitive advantage in the economic and environmental aspect, while at the same time serving a sustainable development for society as well as the organisation. Thus, it could be argued that the sustainable business model concept model might eventually supersede the business model concept much like sustainable competitive advantage has superseded competitive advantage (Grant, 2010).

As partly set out before, drawing from common business model definitions, Gassmann, Frankenberger and Csik (2017) developed “the magic triangle”, a business model framework that consists of four central dimensions: “the Who”, “the What”, “the How” and “the Value” (Böhm et al., 2017). With regards to these descriptions, the characteristics of a sustainable business model according to the “magic triangle” are described below (figure 15 & 16) (Böhm et al., 2017; BCG | Young & Reeves, 2020).

Figure 15 | The magic triangle of business models according to Grassmann (Böhm et al., 2017, p. 6)

Figure 16 | Sustainable business model and characteristics, according to the "magic triangle" (Böhm et al., 2017; BCG | Young & Reeves, 2020)

Who?	• Customers, appreciate a value creation with an environmental and societal surplus
What?	• Reshape business ecosystems for sustainability • It is necessary to describe the company's business activities in terms of open, clean, environmentally friendly, renewable and integrative characteristics
Value?	• Enrich shareholder returns and net positives for stakeholders on environmental and societal dimensions • Increase differentiation and competitiveness • Reduce the potential of commoditization
How?	• Exhibit network effects, which are accumulate value and reshape value chains

Summarizing all related definitions in the current literature, sustainable business models are considered to be a modification of the conventional business model concept, with certain characteristics and several embedded goals: 1) incorporate concepts, principles, or goals that aim for sustainability; or 2) integrate sustainability into their value proposition, value creation and delivery activities, and/or value capture mechanisms.

Recent studies and authors argue that social- and environmental challenges are developing towards being the main driver of innovation. These trends will clearly shape corporate innovation culture in 2020 and beyond (Hofmann, 2019).
Integrating technology innovation, e.g. clean mobility and technology, with business model innovation is multidimensional and complex, but considering sustainability will clearly lead to lasting competitive advantages and create sustainable value (Hart, S. L. & Milstein, 2003).

Described changes in electric mobility and sharing will cause a completely new value proposition. The underlying business logic will be replaced to offer a new product-service system (Schaltegger et al., 2016). Distinguishing from competitors via the provision of charging services, combined with multi-modal mobility offers is of high importance. Thus, here the focus is also the successful definition of new sustainable and service-based business models, in order to assure supplementary advantages and an accelerated market penetration for new electric mobility charging solutions (Navigant, 2017).

Because of this, companies are forced to change the way they think about products, technologies, processes, and business models. Developing a new business model requires the investigation of alternatives to current ways of doing business as well as understanding how enterprises can meet customers' mobility needs differently.

Described megatrends, the new social role of a car and the growing demand for mobility services are also permanently changing the role of the traditional German automobile manufacturer.

New business areas are developing with great dynamism around the provision of individual mobility.

As a result, new players are entering the business of individual mobility, which has so far been dominated by car manufacturers. Moreover, with this, the manufacturers run the risk of losing their interfaces to their customers. Yet these forms of mobility are not a substitute for the traditional sales model. For car manufacturers it is rather a matter of anchoring a sensible selection of the new possibilities in an integrated business model: sales, aftersales, financial- and mobility services. In the course of electric mobility, it is therefore important for car manufacturers to define an integrated business model that also includes the offer of electric charging. On the other hand, in their previous role as providers of mobility, car manufacturers are predestined to respond to the changing demand patterns with intelligent solutions; after all, on the basis of their long-term customer relationships. The difficulty lies in leaving well-established paths and using existing know-how in a completely new way (Capgemini Invent, 2019).

Audi recently published a similar roadmap as TESLA. In the medium term, Audi intends to build up its own premium-charging infrastructure in large cities. Audi's charging stations are to be set up like petrol stations. Audi is also looking for partners for gastronomy, consumption or co-working areas. Small brand- and merchandising headquarters are also possible. The costs for this are estimated at over one billion euros (Audi, 2021).

Sustainable business models combine many of the concepts that characterize social and environmental values next to the traditionally understood business dimension. The report "model behaviour" describes 20 business model innovations for sustainability. With regards to this publication elements like environmental impact, social impact or financial innovation were listed. Examples for sustainable business models in this regard are (Wpn, 2020):

- Environmental impact, e.g. models Closed-Loop Production, Produce on Demand
- Social impact, e.g. models Cooperative Ownership, Inclusive Sourcing
- Financial innovation, e.g. models Crowdfunding, Freemium, Pay for Success,
- Diverse impact, e.g. models Product-as-Service, Shared Resource

Jonker describes the second example of sustainable business models, as well with the following dimensions (Jonker, 2012, p. 20-22):

- “Sharing – “Models are based on a variety of collaborations such as sharing people, ideas, equipment, property, data and transport. […] Sharing knowledge and networks also seems to be an important basis for conducting business in a lot of models; […] constantly exchanging tangible and intangible things between different parties is the essence of these new business models.”
- “Creating – “Models based on multiply value creation. It creates the win-win situation for involved stakeholders.”

Mobility solutions and related sustainable business models for efficient and resource-saving transport systems can be created, also to support newly arising Smart City-concepts.
In recent years, more and more cities are recognizing the need to address and counteract an emerging urban crisis. A crisis with multiple dimensions, including the degradation of the quality of life as a result of greenhouse gas emissions, threats from climate change, and the urgency to develop policies that innovatively support a move toward “Green Cities” or “Smart Sustainable Cities” (García-Muiña, 2020). Smart City describes the concept of a city in which the use of technology is intended to solve very different problems of urban development. In contrast to a "normal" city, a Smart City should be more efficient, sustainable and progressive by means of digitization. This can affect infrastructure, buildings, mobility, services or security. The goal is for technologies to be networked by the city in such a way that the quality of life of the inhabitants is very much improved (García-Muiña, 2020). Smart cities must provide effective smart mobility solutions while supporting innovation, fostering a collaborative ecosystem, and achieving sustainability goals. These challenges are part of the rapidly changing landscape of urban mobility as seen through the perspective of a Smart City. For them, “mobility-as-a-service” (MaaS) offers a paradigm shift from transportation services that are mostly provider-centric to a customer-centric model, where service offerings adapt to fluctuating demand and usage patterns. Mobility-as-a-service is the provision of mobility on a temporary basis. It involves the integration of several means of transport into a single mobility service that is accessible to the user on demand. With MaaS-products, the user is thus no longer tied to owning his own means of transport. This benefits not only private individuals, but also municipalities. According to forecasts, the MaaS-market is expected to grow at a compound annual growth rate (CAGR) of 32% to 37% over the next five years and reach a global market size of $158 billion to $174 billion by 2024 (United Nations, 2020). One of the biggest opportunities for MaaS-innovators is to solve an essential problem for urban travel. Particularly for commuters who do not own a private vehicle, or who want to optimise their ecological footprint, MaaS offers a simple solution to the "last mile problem" and complex end-to-end trip planning. Many travellers still face the challenge of how to get from their home to the public transportation departure point, or from the bus stop to their individual destination. As a result, these commuters often rely on a private vehicle, or cumbersome and time-consuming alternatives (García-Muiña, 2020). See summary figures 17, 18.

Figure 17 | Smart Citiy mobility strategies (Gassmann et al., 2018, p. 19; García-Muiña, 2020)

Strategies to address urban mobility challenges and solve urban mobility problems are specific to each city and include:

- Developing effective, balanced, safe, and secure public transportation systems, including mobility-as-a-service (MaaS) and other platforms
- Adapting to vehicle innovation and adoption (autonomous, connected, electric, shared, station less)
- Developing policies and strategies to promote compliance with air quality standards and other quality of life measures
- Developing public-private partnerships (PPPs) and working with research institutes to address air quality, congestion, and sustainability issues
- Building sustainable infrastructure - physical and digital - to support innovative mobility solutions from the public and private sectors

Figure 18 | Mobility-as-a-service (MaaS) benefits for Smart Cities (Gassmann, 2018)

Mobility-as-a-service | (MaaS)-mobility model will offer significant benefits to customers and smart cities:

- More transportation choices
- More inclusive and straightforward mobility services
- Attractive first mile / last mile services in conjunction with other mobility services
- Reduced reliance on private vehicles, reducing urban congestion and greenhouse gas emissions
- Introduction and efficient use of multiple modes of transportation
- On-demand transportation needs (to complement traditional public transportation services).
- Need to reduce the complexity of end-to-end trips
- Lack of "first mile" and "last mile" solutions
- Opportunities for public transit agencies to provide more comprehensive transportation services
- Promotion of digital technologies and app-based services (e.g. pay by App)

Consequently, business model innovations may be required to support new sustainable business models. According to Mitchell and Coles (2003) “By sustainable business model innovation, it means business model replacements that provide product- or service offerings to customers and end users that were not previously available. Nowadays corporations are making significant progress in addressing sustainability (Wells, 2008; Boons & Lüdeke-Freund, 2013; Schaltegger et al., 2016; BCG | Young & Reeves, 2020). Despite this progress, only a few enterprises are really exploring the understanding of sustainability and its operating consequences. Only rarely is there a systematic process available that would improve the full potential and limits of sustainability and integrate them into current corporate business models and ecosystems (BCG | Young & Reeves, 2020). Bridging the environmental management concerns in conjunction with economic- and social changes, should be the focus in future (Roome & Louche, 2016). Hendricks (2020), who describes a very simple sustainable business model, summarizes all definitions and listed developments. One theory is that a truly sustainable business model is one that gives as much as it takes (Hendricks, 2020).

According to him, there are several ways to approach the issue of sustainability, but the most elementary is the one, which can unite all stakeholders (Mitchell et al., 1997).
This is: “Kinder business proceedings simply attract more customers - Use your sustainability as a selling point”, (Hendricks, 2020).

Having said this, this thesis will provide a framework for a sustainable business model innovation against the backdrop of electric mobility and public charging. Schaltegger et al., 2016 describes a sustainable business model innovation, which is perfectly related to new sustainable charging business models.
According to Schaltegger, a sustainable business model innovation is the creation of “modified and completely new business models, which enable integrative and competitive solutions by either radically reducing negative and/or creating positive external effects for the natural environment and society” (p. 209). This will lead to an understanding how new sustainable aspects create a newly shared value, achieving profit and in parallel a positive environmental and societal impact. Frequently mentioned new business models in the context of electric mobility are balancing out the different cost structures of combustion engine-based and electric vehicles as well as technological uncertainties, or bringing different industries together.
Regarding electric mobility in Germany, sustainable business models have recently been fostered. Research in the field has shown that supporting policies are acquiring an important role for future business model success and thereby assuring the intended sustainability. Awareness is expanding as to how dependent future sustainable business models might respond in terms of changing regulations (Leisen et al., 2019).
This also refers to electric mobility and charging solutions. For instance, in case of the fuel cell scenario, the future role of hydrogen is mainly influenced by political regulations and whether it is politically desired or not. New actors in the energy business are achieving market scale by providing innovative business models, also in terms of charging. Furthermore, a shift towards alternative energy resources further challenges companies and might bring opportunities for business models focused on active customer participation and environmental and social value creation (Birkin et al., 2009). Surprisingly concerning electric mobility and battery second use industries, the focus is mainly oriented on economic aspects without integrating social- and environmental dimensions. This is especially because of the difficult and expensive recycling of lithium-ion batteries the re-use aspect should be much more encouraged as a fundamental aspect of a sustainable business case.
The new business models are based primarily on better capacity utilisation, extended use, secondary use options or the general acceptance of the electric mobility solutions. In the context of the charging infrastructure, this would mean that private infrastructures with low connection capacities will dominate, but individual public charging points with simple billing systems and IT-supporting applications can increase acceptance of charging and electric mobility as a whole. The related empirical findings of this research project identify the crucial aspects of sustainable business models to finally obtain economic competitiveness for the future mobility hub. Moreover, the sustainability of charging infrastructure business models is beneficial to the electric mobility industry, because better developed infrastructure can provide better support facilities and services for electric vehicles.

Thus, more and more people are likely to opt for electrical driving instead of fossil-fuel cars. In this way, the healthy development of the charging infrastructure industry is an important basis for the widespread use of electric vehicles and reducing environmental effects on society.
The initial result is that the future mobility hub, offering mobility-as-a-service, encourages road users to choose modes of transport other than the car more often, which is ultimately the most effective measure for the transition to an overall sustainable mobility and decarbonisation. Indeed, the aim of this thesis is to show how an overall sustainability can be part of a favourable business model approach.

3.3 Business model for public charging infrastructure

3.3.1 Current uncertainties in terms of the business model

According to Hannon and colleagues, starting new business models always involves a certain risk (Hannon et al., 2013; Duvall, et al., 2019). Similarly, Wiederer and Philip highlight certain risks including, of course, the business hazard of becoming obsolete due to improved technologies or new competitors in the market (Wiederer & Philip, 2010). On the other hand, there is also the opportunity to gain competitive advantage (Bohnsack et al., 2019).
Since the network of charging points must be nationwide and therefore a large number of charging points must be set up, the first and most important location criterion for financing a charging point is the basic capacity utilization. “They are kept there long enough and frequently enough so that the construction costs are amortized as quickly as possible” (NPE, 2015, p. 13). The so-called "mayor pillars" at locations that do not actually make sense will, however, continue to play solely a role for presentation and image reasons (Agora, 2016). In the same way, Aurora (2016) states, that utilisation rates are the strength of each business case, which will be affected by the mix of consumer behaviours, e.g. charging at home or at a public charging point.
In general, there is an overall commitment about the importance of public charging infrastructure for the market penetration of electrical vehicles. However, there are only a very few research activities, in fact addressing the question how much charging infrastructure is exactly needed for a profitable market. In parallel also only addressed in some studies, the question how strongly charging infrastructure encourages electric vehicle sales (Helmus et al., 2018). The reasons behind are manifold, but data availability problems or quantum leaps in electric vehicle technology could be mentioned. “Electric vehicles and charging infrastructure will grow and coevolve together with patterns that still remain largely unclear” (Amsterdam Roundtables Foundation, 2017; Hall & Lutsey, 2017b, p.13; Helmus et al., 2018). Several governmental studies also acknowledge these theories. It is a common-sense approach, to install charging infrastructure in line with demand (NPE, 2015). But determining actual demand for the different types of charging infrastructure is difficult and research knowledge is only available in some cases.
Maybe due to this reason, the European Parliament only addressed national governments in building up an “appropriate number of electric recharging points accessible to the public” until 2020 (NPE, 2018) instead of setting specific targets as suggested by the European Commission (NPE, 2018).

For Germany, the European Commission suggested a target of 1.5 million charging points (for BEV) in total until 2020, 150,000 of which are public. This reference value is based on a supranational top-down approach to address geographical coverage as well as user demand. User demand in Germany is derived from the forecasted number of electric vehicles (Proff, 2015).
However, the general aim of public charging infrastructure is “to provide a social infrastructure, i.e. to guarantee a minimum standard of service at low cost to the widest possible public” (Funke et al., 2019, p. 74). “A demand-oriented installation of charging infrastructure might not be in line with this task of building up the aforementioned social infrastructure” (Funke et al., 2019, p. 73).

Higher population density goes along with a higher probability of demand for a charging infrastructure. And people in areas with a higher population density might be dependent on a public charging infrastructure, due to not having house ownership and the possibility to charge at home. But a strategic rollout of charging infrastructure involves both, that is, building charging facilities in high and low populated areas. In this context, it is also worth mentioning again, the general reason behind market failure of new technologies and related infrastructure is resulting from missing markets. The private market has no incentive to provide such goods, hence market failure. Typically, government must subsidize the private sector for a first deployment (acatech, 2010). The same applies to electric mobility and charging: as long as there is no nationwide network of filling stations, buying an electric car is not appealing to anyone. Nevertheless, as long as there are no electric cars, there will at least be no private investment in the provision of charging stations. To solve such a "chicken-egg-problem”, first and foremost, public start-up financing must be made available here (acatech, 2010; Helmus et al., 2018). For the government, the key is to ensure the optimal, efficient provision of the "charging mobility infrastructure" to assure a successful ramp-up of electric mobility. Moreover, in the medium term, the business case for charging infrastructure should not be based on governmental funding (Greene et al., 2013).
In conclusion, for a holistic view, the construction of a public charging infrastructure has to be regarded from different perspectives (Stubbs & Cocklin, 2008; NPE, 2015). Consequently, research on charging infrastructure set-up is very rare and heterogeneous. Approaches range from the discussion of location criteria to the estimation of charging infrastructure based on complex mathematical models (Stubbs & Cocklin, 2008; Agora, 2016). But according to Helmus and colleagues facilitating charging hubs typically applies the two rollout strategies; demand-driven and a strategic variant (Helmus et al., 2018).

Most studies agree that the installation of public charging hubs is the most sensible and cost-effective option. However according to the DLR | Deutsches Zentrum für Luft- und Raumfahrt, this part of the value chain is also "associated with most risks". The reason is that the construction of new infrastructure is generally combined with very high investments, whereby it is not foreseeable when these will pay off according to a volatile framework (DLR & ARAL AG, 2019).

Other studies show that users of battery-driven e-vehicles charge mainly at home and they are not prepared to bear the additional costs at a public charging point. Besides important insights according to Weiss et al. (2019) are the average driving behaviour relating to estimated utilization rates (cited by Plötz, in Funke et al., 2019). In the underlying studies, different datasets were combined in order to analyse the average driving behaviour in Germany. The authors indicated that the normal daily trips of almost 30% of the vehicles are less than 100 km on all days of the year except for four days (Funke, et al., 2019).

According to Plötz (2019), however, in a similar analysis, 35% of German car users drive more than 100 km on at least 20 days per year (Funke, et al., 2019). These analyses also negatively affect the future population and requirement for public charging infrastructure. In a similar way, Neubauer and Wood determined that 75% of the yearly kilometres per vehicle could be performed with a BEV with an electric range of 120 km with no need for public charging infrastructure. The availability of public fast charging infrastructure could even raise this percentage up to 90% (Funke, et al., 2019).

The authors found that increasing the vehicle's electric range to above 100 km had a comparable effect to deploying public fast charging for BEVs (Funke, et al., 2019). However the usage of detailed local travel data is a huge workload and can only be performed with massive IT-support, these kinds of studies are often only focusing on specific city areas. In the long term research studies covering the cost of charging sites are often theoretical and do not consider the real charging demand of individual e-car drivers. For instance, Jabbari and MacKenzie (2017) examined the trade-off between availability and the cost of a charging station using a queuing model without considering real-life (cited in Funke, et al., 2019). On the other hand, Jochem and colleagues' study "optimizing the allocation of fast charging infrastructure along the German autobahn" indicates the significance of vehicle range and the desired coverage value. Within this analysis, twenty optimally allocated fast charging stations along the highways already lead to a coverage of about 62% (100 km vehicle range) or even 83% (150 km vehicle range) of all trips (Jochem et al., 2015). In parallel with reference to Pagani new grid management solutions and controlled charging approaches combined with these individual preferences in regards to charging at home, at work or at public chargers, are causing significant economic- and technical uncertainties (Pagani et al., 2019).

Besides psychological effects of "range anxiety / -envy" and charging behaviour, the impact of technical development on the need for public charging infrastructure is of great importance. The required charging infrastructure types could change and resonate with technological progress.

An extended driving range, e.g. due to a higher energy density of new battery technology, will probably substantially affect the need for public charging infrastructure. Finally, for infrastructure operators, the profitability of the stations is essential, being based on high population and profit. Contrarily the energy transition and increasing renewables shares could notably influence the location and timing of charging and result in a shift from home overnight charging to daytime public- and workplace charging.

The public charging infrastructure should therefore be expanded with a sense of proportion (Proff, 2015, p. 14). But according to National Platform for Electric Mobility (Proff, 2015, p. 20) only a wide-spread charging infrastructure can increase customer acceptance of electric vehicles; thus a compromise between customer acceptance and profitability needs to be found.

The National Platform for Electric Mobility (Proff, 2015) summarises this dilemma in a working paper: “to establish and finance a public charging infrastructure is currently not yet feasible from a purely private economic point of view. The reason behind this is that even classic supplementary business-purposes, such as the leasing of advertising space, do not yet automatically enable an economic operation” (NPE, 2018, p. 17). Currently, first energy supply companies are investing in public charging infrastructure, but primarily as an image project and not for economic reasons (Helmus et al., 2018).
It is likely that the economic problem of expanding the public charging infrastructure can be solved in the medium term by subsidies (Helmus et al., 2018). That is why also the German Government is providing subsidies aimed at overcoming the “chicken-egg-problem” between electric vehicle sales and electric vehicle charging infrastructure (Helmus et al., 2018). But although government subsidies are available for more rapid expansion, the costs incurred are usually not fully covered nowadays (Funke, et al., 2019).

The latest developments and the experiences from the energy transition efforts show that an overarching concept and a binding framework are necessary for a continuous expansion of the nationwide infrastructure. Here, the German Government has a duty to define nationwide targets and milestones for the ramp-up of charging points and to coordinate these at least. Electric mobility with its infrastructure is a spatially relevant challenge, which should be strategically addressed at this level in order to promote sustainable mobility (Horx, 2019). Private operators see advantages in the government providing a clear framework. On the contrary, this could accelerate the creation of industry standards and thus enable a faster and economically attractive scaling of e-mobility (IRENA, 2019).
Financial incentives or funding programmes can temporarily support the goal of setting up charging points nationwide and establishing them in the emerging market. Municipalities could even become operators of charging stations. The stakeholders involved, must coordinate more closely with each other in order to help electric mobility achieve a breakthrough (Mazur et al., 2015). This will create new ecosystems with different players from both established industries and new industries that do not yet play a significant role in today's mobility now. Steering by the public sector is all the more important in order to set a solid and long-term framework or to avoid uncertainties (Zott et al., 2011).

Hence, this research project focuses on sustainable business models for public charging approaches.
Here it is of high importance, to take the multidimensional charging types and mobility behaviours into account in order to get an optimal understanding for the research gap and the complex electric mobility ecosystem (Rommerskirchen et al., 2019).

3.3.2 Clear requirement for a sustainable business model | WHY - SUSTAINABILITY?

Despite all the uncertainties and considering changed mobility behaviours, there is a clear need for commercially sustainable public charging infrastructure (Bohnsack et al., 2019).
In this regard, Madina et al., (2016) observe innovative business models in networked environments, as electric mobility. For Madina and colleagues, this requires a global approach to ensure that all the actors involved obtain benefits in the medium term (Madina et al., 2016). This refers to “communities of economic actors whose individual business activities share in some large measure the fate of the whole community” (Moore, 2006, p. 33). According to the same authors, a so called “sound business model” has to be defined for charging services, which enables a coverage cost and a profitable operation while, in parallel, electric vehicle users are offered a charging price which makes electric mobility comparable to internal combustion engine vehicles (Madina et al., 2016).

There is still a lack of research material available in terms of the details of electric vehicle charging infrastructure and related economic sustainability. In parallel, there is only some literature focusing on charging infrastructure and assessing its performance.
Very view studies deal with the connection of stakeholders who are directly concerned with decision-making for charging infrastructure rollout based on performance (Helmus et al., 2018). While the electric mobility hype in Germany in 2010-2011, experts warned that, there is no business case for public charging infrastructure available. For instance, in 2012 Schroeder and Traber investigated the uncertainties of electric vehicle rollout and showed at the very beginning that at low electric vehicle penetrations the investment in fast charging infrastructure is hardly profitable (Schroeder & Traber, 2012).
Madina et al. (2016) analysed the economic feasibility of various charging infrastructure business models via considering different roles in the ecosystem of electric mobility. These authors focused on the transaction volume and additional pricing options (in kWh), which were indicated as the main driver for a profitable business case. The weekly transaction volume is the main performance indicator in this research, showing the overall usage and effectiveness of charging infrastructure (Madina et al., 2016).
What is particularly missing is information for new fast charging business cases or hydrogen infrastructure. Important components of any business case evaluation comprise data on cost, tariffs, capacity and the utilization rates. In particular, the utilization rates hardly feature in the peer-reviewed literature; they are only exposed in a few project reports mentioned (Schroeder & Traber, 2012).
The research mainly integrates estimations about driving behaviour. Cost components include initial capital expenditure (CAPEX) and operational expenditures (OPEX), which, in turn, comprise electricity cost, maintenance and other operational costs (O&M) (Schroeder & Traber, 2012). Via these approaches, Schroeder and Traber (2012) provided early insight into the return on investment available for public rapid chargers, identifying many of the set-up and operating costs likely to be incurred but concluding that market-driven rapid charging roll-out was fairly risky (Schroeder & Traber, 2012). This analysis is still valid today; it is an important basis for further research.

Jochem et al. (2015) have made much more recent contributions. Jochem and colleagues (2015) evaluated the optimal allocation of public charging infrastructure along the German autobahn.
According to this research, an economical rollout and a sustainable business case would be possible under certain cost estimations. In further research, actual figures for initial investment (CAPEX) and running costs (OPEX) in Great Britain are considered. In addition, user data along highways are integrated. This sensitivity analysis conducted between mark-up factor and demand indicates that pricing will be very sensitive to demand, and suggests mark-ups to recover the investment costs. Proposed by Jochem et al., these surcharges have to be higher than 20% (Jochem et al., 2015).

Other researchers are assisting governments and private investors to understand that, with careful policy support, a business case does exist (Serradilla, et al., 2017). Considering the research by Serradilla and colleagues, it seems that, to date, real cost data for fast charging solutions are only available in a very few cases. These missing databases limit policy decisions and delay the definition of economic models to encourage private investment (Serradilla et al., 2017). From Serradilla and colleague`s point of view, it is of particular importance to take into account that charging infrastructure is only one part of the so-called holistic e-mobility system. Hence, the overall value proposition, its cost and revenue model via initial investment and operation are, in parallel, influenced by charging protocols, outlets, power, location and accessibility, communication and control systems and payment mechanisms (Serradilla et al., 2017).
Private investors and electric vehicle manufacturers currently continue to avoid capital expenditures in charging infrastructure due to missing guarantee of return. About Serradilla, this is difficult to assure and obtain relevant data in this nascent market (Serradilla et al., 2017). In particular, due to the fact that recharging infrastructure is not part of the traditional activities of existing German car manufacturers, there are also ongoing debates about who is responsible for provision and ownership of public charging infrastructure in general (Serradilla et al., 2017).

Charging infrastructure networks are resulting in many business opportunities. Hall and Lutsey (2017a) are considering governments in the role to catalyse these markets with policy and pave the way for business cases. Electric power utilities could especially play a key role (Hall & Lutsey, 2017b). Governments and business should align their overall activities and coordination to ensure a robust and profitable charging infrastructure network, thereby setting the foundation for the transition to electric mobility. For this reason, more research is needed to determine the impact of public charging infrastructure on electric vehicle purchase decisions. This is key to the understanding and prediction of sustainable user demand for public charging infrastructure and a related sustainable business case purely driven by the number of electric cars.

3.4 The future role of the motorway service station, influenced by new mobility trends

3.4.1 Changing mobility trends and behaviours

Regarding the changing mobility trends and mobility behaviours, several scenarios exist for future development. These scenarios differ in mobility patterns. In terms of the first development path, mobility behaviours are almost not changing. People are only buying a “greener” car, not really changing their travel behaviours (Geissdoerfer et al. 2018). Another scenario predicts more transformation in mobility behaviour, especially more active travel planning, mixed use of multiple transport modes, and perhaps less private car ownership. Notably it can be assumed, that there will be a considerable increase of car-sharing organisations (Dijk et al., 2013).

Car-sharing or car-pooling means, that a car is rented on a per ride basis from an organisation which services and owns the car. Customers can choose among a wide range of vehicles, allowing for customized choices. Organised car sharing is becoming a highly professionalized business. Providers attract mainly non-car owners, but they also encourage people to sell their car (Dijk et al., 2013). It can be expected that the considerable rise of car-sharing organisations will continue in the future, with further positive effects for electric mobility and charging business cases. Therefore, car-sharing organisations are emerging as a key force influencing the directions of electric mobility development and commercialization (Dijk et. al, 2013). Car-sharing memberships eliminate the currently high purchase prices for electric cars and reduce significantly the cost burden for e.g. insurance, maintenance and depreciation. Car sharing and car-pooling are already beginning to change the habits of consumers, by shifting away from vehicle ownership to shared mobility and to mobility-as-a-service (IRENA, 2019). Several research projects also highlight car sharing, having the potential to satisfy individualized transportation demands in a sustainable and socially beneficial way, by decreasing the demand for cars, lowering emissions, reducing traffic and increasing social cohesion amongst sharers (Prettenthaler & Steininger, 1999; Shaheen & Cohen, 2013; Chase, 2015; Loose, 2016).

The most progressive path also assumes investments in modal transfer and mobility hubs, which allows transport modes to link via new IT-devices and a complete policy change (e.g., new taxes, subsidies). In the context of this most progressive scenario, an Arthur Little study clearly investigated digitalization as one of the major driving forces towards a mobility system upgrade, in which mobility will become “a truly connected system” (Arthur Little, 2019, p. 7). Guyader and Piscicelli (2018) highlight, that mostly due to IT-technologies and the emergence of more collective forms of consumption, people have changed the way they gain access to products and, in particular, their attitude towards ownership (Guyader & Piscicelli, 2018). In connection with mobility, individuality is no longer tied to owning one's own car, but rather to self-determined mobility management, which goes hand in hand with the use of a smartphone (Guyader & Piscicelli, 2018).

Smartphone applications can plan a journey, hire a car, keep people connected while travelling, and pay for the trip through an E-wallet (Sumantran, et al., 2017; Wildemann, 2018). For the young generation, especially, a car is no longer a status symbol, quality of life is more important than ownership and environmental protection and sustainability are of great importance.

Wildemann (2018) argues that a car of one's own was regarded as a status symbol for many decades and in many regions, this is still the case, especially for older people. For the generation under-35-years-old the preference is often car-sharing or other means of transport in their daily lives (Wildemann, 2018). For Herwig (2017) the main aspect of the sharing economy is a transformation in consumer thinking (Herwig, 2017), meaning being more concerned with usage than ownership and multi-modality, as long as what is on offer meets their individual needs (Arthur Little, 2019, p.14).
Younger people have already been using alternative mobility services and are thus promoting the development of new mobility models. (Herwig, 2017). According to Guyader and Piscicelli, there has already been a clear paradigm shift in the mobility sector with shared mobility business models and offering temporary usage of a car through access-based services, e.g. car sharing, ride sharing, car leasing. This “sharing economy” is a new phenomenon (Guyader & Piscicelli, 2018) but it is safe to say that the young generation of today will shape the mobility patterns of tomorrow (Herrenkind, et al., 2019). In this context, business model portfolios employed as a diversification strategy are also new (Guyader & Piscicelli, 2018). The younger generations in particular have adapted well to life with the new business models associated with the sharing economy. Car sharing services, such as car2go or driveNow, have become indispensable in major German cities, and taxi Apps for ordering a taxi are very popular.
Alternative mobility concepts will gain in importance in the future, especially in view of the mega-trend of urbanization, meaning that more than half of all journeys are made in cities (Herwig, 2017). Besides, advances in autonomous-driving technology promise to resolve road-safety concerns, reduce the cost of transportation and expand access to mobility (Yun et al., 2016).

Finally, an increasing proportion of young drivers in Germany are using alternative means of transport and showing multi-modal driving behaviour. There are miscellaneous reasons behind.
For instance the described changes in how mobility is viewed or improvements in and promotion of alternative transportation (Kuhnimhof et al., 2018). The financial crisis in 2008 resulted as well in changed mobility behaviour and resulted in higher cost awareness (e.g., Nielsen, 2015; Ulfarsson et al., 2015; Papagiannakis et al., 2018) and shifted mobility patterns away from car ownership (Kuhnimhof et al., 2018). These developments reveal the change in the travel behaviours of young people, pushing towards the demand for new multi-modal mobility services.

In reference to Arthur Little (Arthur Little, 2019, p. 14-38), general mobility habits are clearly evolving and mobility behaviours are heading for an interconnected multi-modal mobility system, with increased convenience and efficiency, meaning a significant shift in mobility patterns towards shared ownership and moreover inter-modality (Arthur Little, 2019, p. 14-38). The challenge is to assure that these new services are embedded. Mobility traditionally meant to go from point A to point B. Now new mobility operators have to reconsider the overall mobility system. Different modes of transportation are increasingly interconnected, supported by new IT-devices and mobility becomes more of a service model with many options for transportation needs (Herrenkind, et al., 2019; Deloitte 2020).
Sumantran and colleagues (Sumantran, et al., 2017) stressed in their research, that for complex user needs, a multi-solution mobility landscape would be opened up, with access to a full spectrum of technologies, business models and transport modes.

Mobility devices such as cars, bicycles, and microcars will coexist with buses and metro transit systems. The quickest path between two points may involve a drive by car to a metro station, and then travel by public transport to a city centre, followed by the use of a shared bicycle for the last mile. “Uber, Zipcar, Sidecar, Turo, Car2Go, BlaBlaCar, Grabtaxi, Velib, Boris Bikes, … personal urban transportation is acquiring a new vocabulary” (Arthur Little, 2019, p. 14-38). Urban mobility experiences will become increasingly heterogeneous. Each mode or combination of modes will be characterized by specific cost, availability, environmental impact and time efficiency. Around the world, sustained investment in physical infrastructure and digital infrastructures, augmented by the world of smart devices and handheld Apps, has given a huge boost to connecting these diverse modes of transportation (Sumantran, et al., 2017, Deloitte 2020), Dijk has already distinguished in 2013 that new services are appearing, which enable new mobility trends.

The creation of better systems of inter-modality can also be expected to affect car mobility and e-mobility. Instead of using a car for the entire trip, it may be used for part of the trip, in combination with other transport modes. According to Dijk, this requires convenient transfer points (Dijk et al., 2013, p. 142), which are increasingly accompanied by car restricting policies in the city centres and this, may even continue in the future. Better modality systems and problems of congestion have led to cars being used in combination with other modes of transport, for instance traditional public transport, fast trains and electric bikes and scooters (Dijk et al., 2013). Nowadays in congested urban areas, an increase in the use of public transport and bicycles of up to 150% per year can be observed.

Although automobile manufacturers are now able to maintain a continuous growth rate of 1.5% in conventional vehicles, assisted by innovative solutions, the trend is clearly towards alternative mobility options (Wildemann, 2018). According to Horst Wildemann, flexibility and individuality are the top priorities in mobility planning today. This is also reflected in the desire for spontaneous and seamless travel connections that can be planned. The central prerequisites here are the availability of travel information, transfer hubs and the possibility of combining means of transport (Herwig, 2017).

These changing mobility needs will lead to the rise of business models that could transform mobility systems (IRENA, 2019). New business models and related IT-solutions integrate several functionalities, namely charging; trip planning, booking, payment and ticketing/billing (IRENA, 2019).

The clear increase of the sharing economy and a trend in the mobility sector presents opportunities for new firms to operate different business models simultaneously (Guyader & Piscicelli, 2018). In the shared mobility sector, for example, “carsharing,” “bikesharing” and “ridesharing” were identified as different business model categories (Guyader & Piscicelli, 2018).

Future mobility systems and related offerings should therefore be intermodal, personalized, and convenient, connected, and encourage the usage of more sustainable ways of transport. This implies a shift away from owning a car towards the use of integrated multi-modal mobility solutions consumed as services. Convergence through digitalization constitutes a major opportunity to reinvent mobility systems as they gradually evolve to embrace “mobility-as-a-service” (Arthur Little, 2019, p. 17). Concerning the customers` flexibility, currently there is the option to switch from traditional transport models to new mobility modes, and a survey reveals that one third would be willing to change immediately (Arthur Little, 2019, p. 17).

One example for an innovative business driven by new mobility trends is the idea of the start-up company “Chargery” located in Berlin (Damm, 2018). The business idea is to be able to recharge e-cars at any location. This can be implemented by means of a mobile charging station for business customers. The electric cars no longer have to find free charging stations, as Chargery brings their mobile charging stations to the cars, no matter where they are located in Berlin. The business model is actually quite simple: The DriveNow cars report to Chargery if they require recharging. The license plate and GPS data are transmitted and a Chargery driver is dispatched to the same car by bicycle with the charging station on a trailer. Chargery has found a profitable niche with its mobile charging stations (Damm, 2018).

3.4.2 The future charging station is a mobility hub

It is very important for people to easily use various modes of transportation, such as shared, multi-modal mobility services (Duvall et al., 2019). According to Dijk, this requires “convenient transfer points” (Dijk et al., 2013, p. 142). Thus, the filling station becomes a mobility station. Increased mileage of passenger cars and commercial vehicles offers together with new mobility trends the best prerequisites for enlargement of the traditional charging station business.

This way the charging station will develop into a mobility hub. Especially in big cities or alongside of motorways the filling station is becoming a service station for autonomous fleets of "on-demand-mobility". With its convenient location, it can make use of a wide variety of mobility offers and link new service areas with each other. On the other hand, electric vehicle users are expected to drive to traffic hotspots for different reasons (shopping, leisure…), but not for charging their electric vehicles as the main goal (Madina et al., 2016).

The possibilities for developing the filling station business as a cornerstone of mobility in the future are therefore manifold. The task of the aforementioned DLR-study “the mobility station and future electric mobility trends in the medium- and long term” was to filter out the most promising approaches for filling stations based on the determined mobility behaviour. Petrol pump, charging station, battery dispenser will reflect the new fuel mix**.** Electric cars and hybrids are particularly suitable for inner-city short distances. Therefore, the future petrol station will, on average, cover three to four ultra-fast charging stations, as well supplemented by petrol and diesel pumps; eventually they will offer biofuels or synthetic fuels and fuel dispensers for natural gas or hydrogen. With ultrafast charging via charging power of up to 400 kW, the batteries of electric cars can be charged quickly for a range of up to 145 km. This will also allow a short stopover on the way.

For many drivers, this extra, multi-modal flexibility will fit much better in their everyday lives. However, it is not only cars, which will be increasingly powered by electricity in 2040. In the cities more and more two-wheeled vehicles are electrically driven. The number of e-bikes and e-scooters will also increase. In 2017, 720,000 e-bikes were sold in Germany. This corresponds to a 19%-share of the total bicycle market. Moreover, the market share will continue to rise (Schleinitz et al., 2017). In addition, the numbers of E-scooters have increased sharply in recent years. Related straight delivery vehicles and couriers on tightly scheduled tours or tourists will be dependent on loading facilities. Petrol stations will then offer the required charging services. The future petrol station is therefore a hub and transfer point. In large cities, people can travel by various means of transport whether by car, train, bus, taxi or bicycle. The demand for flexible mobility services is particularly important here. There are still separate stops for all of them. With an increased offer of car sharing possibilities, future autonomous vehicles or even air taxis, the future gas station can be a central hub for all travellers. For instance, there are several options: getting to the destination by train or taxi and travelling on an e-bike or being transported by the autonomous carpooling vehicle, which picks up passengers. For this intermodal transport to be offered at filling station is feasible, because there will be sufficient space and a traffic-favourable situation.

Arthur Little finally emphasizes the new requirement of building a culture of service excellence for companies without imposing additional costs (Arthur Little, 2019, p. 14-38). Mobility offerings should therefore be expanded, “delivering user-friendly multi-modal solutions” rather than only “delivering transport” (Arthur Little, 2019, p. 14-38).

In general, the shop and bistro business is supplemented by gastronomy offers at petrol stations. Due to the tight time budget, there is a general trend that in future more people will eat outside home or shop spontaneously. This is why a filling station increasingly offers a flexible and high-quality “supply on the move” (Arthur Little, 2019, p. 14-38). Overall, people are very mobile and travelled around 3.214 billion km per day in 2017, which is resulting in an increase of 4%, compared to the last mobility survey in Germany (MiD) in 2008. Transport performance has thus increased significantly. The main reasons for this were the rise in population and economic output. The number of people in employment, for example, grew by around 8%. The REWE Group (a German supermarket chain) is picking up on this trend for its charging station concept (Wildemann, 2018) and entered into a cooperation agreement with ARAL Petrol Station Group – offering "REWE-to-go" (Lotz, 2018).
At large city gas stations, gastronomy and retail offers are becoming more of an independent pillar of the petrol station business, even more than it is today. Even the roof of the future petrol station will be used, possibly as a landing strip for air taxis. Because the vision of flying daily could sometimes become true, even if only for a smaller target group. Electric air taxis, similar to helicopters, could be used for the transport of people. They enable passengers with little time, to avoid the dense city traffic and to escape from the crowded streets. Inner-city stations offer a good landing possibility, especially since air taxis are most likely to land along today's traffic axes. In their perhaps multi-story form, petrol stations could additionally have a related waiting area and a charging facility. In this case, one major recommendation according to the key debates is, that a range of mobility services should be fixed, which are systematically defined, developed and replicable. This also means the provision of suitable concepts, approaches and methods to develop services products. Services should be merchandised in general as are material goods or software (Bullinger, 2004)

Currently, there are various business model types available for charging hubs. They are differing with regard to addressed markets or regions, because only via adapting to specific requirements sustainable business success will be possible. Even today, there are numerous operators of charging stations. This covers stations owned and operated by diverse business partners, including public agencies, car manufacturers, energy companies and pure charging operators or first mobility-as-a-service providers (WEF, 2018). In parallel, the latest trend is emerging, meaning that mobility culture is evolving towards shared mobility services and multi-modal solutions. Automated vehicles are becoming all the more crucial, battery technology improves and further technical developments can be foreseen (DLR & ARAL AG, 2019). Society's environmental awareness is rising and city centres are becoming increasingly green or restricted to private transport (DLR & ARAL AG, 2019).
Against these far-reaching developments, the optimal location for the charging infrastructure will most likely change (WEF, 2018). Home, local and destination-charging stations are expected to meet on-the-spot demands. The transfer from a transport hub to a final destination, as well mobility-as-a service solutions are gaining in importance. According to the WEF-conference paper, intensified user demand will especially arise for electrical charging close to the main public transport nodes or hubs in the outskirts of cities.

These locations will therefore become more profitable, while others may slip into insignificance and are therefore no longer profitable (WEF, 2018). Nevertheless, for sure the service portfolio of the future charging hubs will be enriched via additional services, e.g. car maintenance, car sharing and shopping centres. According to Garcia, the filling station will probably also be a service station for autonomous fleets (Garcia et al., 2019). “From there, charging hubs can become hubs for smart-city services” (WEF, 2018, p. 5).

3.4.3 The future role of the electric mobility service provider

A new type of actor has emerged in the field of transport: mobility providers or -operators. Their business is to provide various mobility services rather than a vehicle or a ride. Initial examples of new mobility providers are car-sharing organisations offering car services in combination with public transport use or charging station operators offering charging possibilities (Dijk et al., 2013). Madina, Zamora and Zabala et al., (2019) clearly emphasize, against the background of electric mobility that new roles are evolving (see figure 19). These new roles in the wide-ranged value chain can be fulfilled by new entrants or by established actors (Schroeder & Traber, 2012). Therefore, Madina, Zamora & Zabala (2016) see the electric mobility service-provider as the new key role. Major provider responsibilities offer electric mobility services; this may include charging and other services. The service-provider is also described as legal entity, with which the end-customer has a contract (Madina et al., 2016).

Especially from the perspective of such charging service operators, the definition of a profitable business model is of key importance. Taking into account the major challenges of electric mobility, that there is only a modest number of users, there is a high investment cost for electric vehicles and charging infrastructure. In parallel for the electric mobility end-users, an affordable charging price has to be assured. A price level, which is equal to the charging of internal combustion engine vehicles, is an additional prerequisite for the breakthrough of electric mobility charging (see also 2.2.2).
The charging service operator offers charging as electric mobility service, which is a service portfolio about the end-customer that integrates charging and, if applicable, other services (business-to-customer B2C). The charging service operator is responsible for operating the physical equipment to supply the charging process, meaning also an overall responsibility for the whole charging session, including the monitoring, maintaining and controlling of selected charging stations. This section therefore briefly describes the status quo of the operator models of service stations in Germany from the perspective of an electric mobility service provider. Several studies analysed, the operating and operator models in Germany and divided them into different groups. First of all the term "operating models" and the term "operator models" are explained in detail below.

The term “operating model” defines how a filling station is operated. Parameters within which the operating model can be designed are (Barr & Prillwitz, 2008):

- The size of the user group (public, semi-public or private service station)
- The number of service facilities
- The scope of the necessary filling station infrastructure
- The scope of the necessary personnel deployment

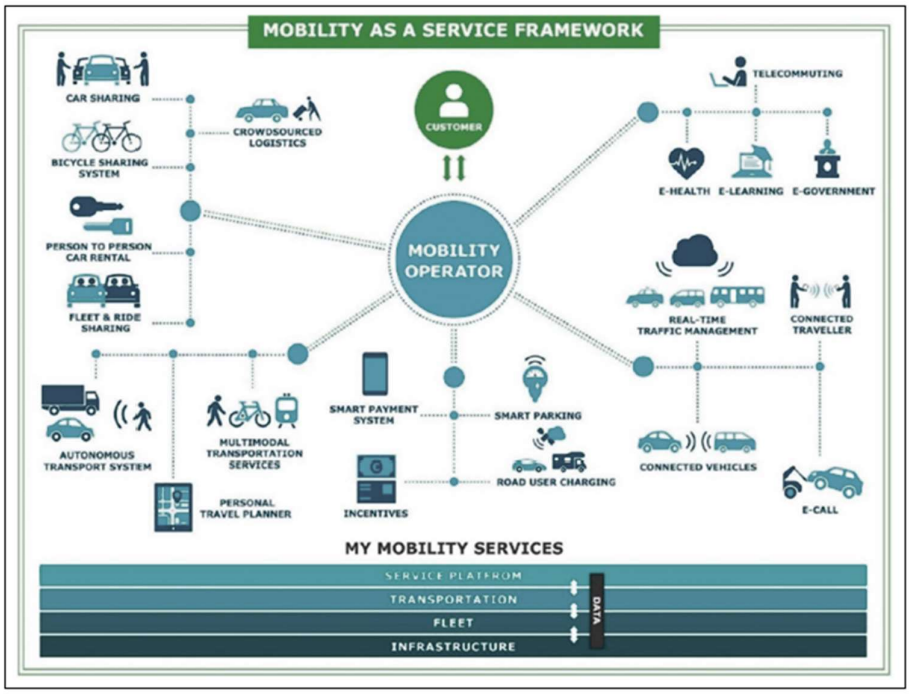
The number of service facilities and the necessary filling station infrastructure and personnel depends primarily on the volume of traffic at the filling station location. The economic efficiency of a filling station has the highest priority. Each service facility incurs additional investment costs, which can lead to a reduction in the amortization period of the total investment of a filling station if it is used sufficiently (Talke et al., 2007). If it is a public filling station without operating personnel, then automatic filling stations are economically operable particularly in rural areas with low traffic volume. In addition, robotic filling stations are currently in test operation at some locations and carry out fully automatic refuelling without personnel. Company filling stations are so-called consumer filling stations for a precisely defined group of users, mostly owned by transport companies or taxi-, bus- and construction companies. They enable a high level of economic efficiency for operators with large vehicle fleets, as savings are possible through a reduced purchase of fuels and the control of refuelling quantities as well as refuelling time (Barr & Prillwitz, 2008).

The term “operator model” is primarily used to describe the company structure of a filling station. Parameters for the design of the operator model are therefore:

- The way in which fuels and products are procured and services are being offered
- The organisational form and the regulation of responsibilities
- The possibility of a flexible design of the offered services and related facilities at the individual filling station locations (Barr & Prillwitz, 2008)

Moreover, operators no longer earn their money with just the original core business, but with the shop business and of course with additional service offerings. This is becoming increasingly important in terms of the profitability of a location. For this reason, so far, operators have had little interest in an expansion; small filling stations in particular cannot finance an expansion to include electricity-charging points. It is likely that small filling stations will disappear as number of electric drives increase. Large filling station locations, on the other hand, are likely to expand. In general, operators will have to check whether the installation and operation of charging stations will be possible at all, at an economic business model.

Figure 19 | The mobility-as-a-service framework (García et al., 2019, p. 5)



The intense dynamics in the development of sustainable business models and mobility-as-a-service explains why the understanding of these terms is still very heterogeneous. A uniform definition and approach have not yet emerged for both.

Based on studies conducted to date, business model innovations are increasingly focusing on sustainability aspects (Talke et al., 2007). Mobility services are steadily concentrating on the user and offer tailor-made mobility solutions for individual needs. This result in the requirement that easy access to the most suitable means of transport or services is included in a bundle of flexible mobility offers for the end-consumer. The aim of a mobility-as-a-service concept is to promote electric mobility in combination with the use of public transport services by facilitating intermodal travel. These aspects need to be investigated further to generate a sustainable business model for the future electric mobility-charging hub. Related descriptions please see chapter 3.5.

3.5 Addressed gaps derived from literature and main research questions

3.5.1 Addressed gaps and research questions

As comprehensively shown, the public charging infrastructure has a significant influence on the overall success of electric mobility, therefore, investment is extremely important.
The dense network of loading points is primarily provided to satisfy the need for comfort in long-distance traffic. In addition, according to the research institute Aurora, it is assumed, that BEV-charging en-route will mostly only be needed for the longest motorway journeys. This application typically needs more expensive, higher-powered charge points to minimise customer-waiting time (Aurora, 2018). In general, e-filling stations on main roads will increase; however, full loads for BEV will probably not be the main business, but reloads. Fast charging with a power supply up to 400 kW enables a full recharging of a BEV in around 10 minutes; allowing a driving distance of approximately 320 km. This brings BEV-recharging much closer to the experience that consumers are used to with internal combustion engine vehicles. Besides these new advantages Burnham et al., (2017) emphasize that several important uncertainties need to be addressed before it is clear how these charging stations might be deployed, including the future development of fuel cell technologies.

Some approaches to achieving a sustainable business case, have already been tested. As discussed before, government incentives are likely to be phased out as electric vehicle deployment increases, so governmental funding is not included in a sustainable business case (Aurora, 2018; BMWi, 2019).
One practical business case example is a study based on long-term analysis in several cities in Switzerland. According to this research, the time to break-even with the electric vehicle-charging infrastructure is up to 50% shorter, when users are charged on the basis of parking fees rather than power sales. However, the revenues from parking fees are shown to be more sensitive to the behaviours and preferences of the users (Pagani et. al, 2019).
Perhaps the simplest charging business model is just selling electricity or hydrogen with a sufficient mark-up to assure cost coverage for the infrastructure investment (Hall & Lutsey, 2017a, Hall & Lutsey, 2017b). The constraints of such a model are obvious, meaning that reaching an equal price level between electricity costs and gasoline, will lead to reduced financial appeal and in case gasoline will be the preferred solution again (Hall & Lutsey, 2017b). In addition, the cheaper alternative of home charging should not be excluded. In case of only marginal mark-ups in electricity price will lead to the choice of home charging. The broad scale viability of an electricity price–based business model depends on the relative cost per mile of driving with electricity versus gasoline. This cost-per-mile equivalence implies that this business model is much better suited for regions with higher fuel prices (Proff, 2015). Yet a significant example are the “kerbside charging stations in Amsterdam”, where electricity price levels are limited and are cheaper on a per mile basis than gasoline. Hence, these charging facilities and their operators are gaining a first profitability through electricity sales alone (Hall & Lutsey, 2017b). But in the medium term, solely electricity sales will not amortize the investment in charging infrastructure or make it profitable. Thus, for a conventional electric vehicle with an assumed annual mileage of 12,000 km and with an average consumption of 15 kWh/100km an annual electricity requirement of 1,800 kWh has to be foreseen (acatech, 2010).

At a net sales price of 14.2 cents/kWh, this corresponds to approx. €255 per year, which is spent net for charging the electric car. The energy price accounts for approx. 40% and the rest for grid fees and other fees (acatech, 2010). The energy supply company thus only has about €100 turnover from the sale of electricity per vehicle. In the case that other technologies are used increasingly, the electricity turnover per vehicle is even lower (acatech, 2010).

A different option is to base the business case on increased retail sales. However, the claim that this BEV-charging process must be fast may lose importance, if society is willing to give up or change its habits. This is the case if a more activity-oriented charging system is accepted in long-distance traffic and the longer charging time is linked to a visit to an Internet café or a shopping centre.
For instance, it should also be considered, that the installation of charging points near a supermarket positively influences the “green image” of the supermarket and, in parallel, attract solvent, eco-friendly customers. Hall and Lutsey (2017b) convinced through their research with the following theory. According to their studies, public electric charging requires significant time and a stopover in terms of long-distance journeys. Thus, future charging stations may represent a way for retailers to attract new customers and increase sales (Hall & Lutsey, 2017b). Using this time requirements as basis for subsequent business models. Meaning deploying charging infrastructure and offering an additional shop- or service portfolio and defraying charging costs. There is some initial evidence that such approaches can be successful in the mid-term. Through the installation of Level 2 battery charging stations at several locations, a major retailer in California could note down an increased dwell time of its customers. Only via the provision of the charging equipment, customers are in average staying 50 minutes longer than before. This increase of almost 260% led to an estimated sales increase of $56.000 in a respective 9-month monitoring period (Michalski et al., 2018; ChargePoint Inc., 2019). Similarly, another US-study in California determined, that close relationship between stopping for charging and shopping behaviour. A fast charging station next to the retailer caused 50% of the drivers to do additional shopping while charging, with an average expenditure of about $18 (Hall & Lutsey, 2017b).
Nowadays, frequently operated service facilities at filling stations with operating personnel include sales shops, washing facilities, catering businesses, car dealership and automotive aftermarket garages. As the market continues to rise, growing use of this model may benefit drivers and businesses alike.
For example, the average profit from the sale of fuel is less than 2 ct/litre and therefore often acts as a customer magnet for the service facilities.
Advertising revenues are another option on which to base a charging station business model. The charging process can also be supplemented with customer-oriented advertising, in order to make the most of the average charging time of 15 minutes. Existing charging infrastructure is increasingly integrating advertisement on petrol pumps. This could also be a fruitful add-on business for the future electric charging hubs in order to offset initial investments. Such advertising could be most appropriate for high-traffic and high-visibility spots. Volta Charging in California is pursuing this business model. This charging operator is providing free Level 2 charging at high-traffic retail locations in several U.S. cities and recording large advertising revenues via video screen advertisement on the charging locations. These advertising revenues may not completely offset the initial installation costs but could be integrated and complete a profitable business case (Hall & Lutsey, 2017b).

Automobile manufacturers are beginning to promote charging infrastructure as well. The most famous example is Tesla`s Supercharger Network, consisting of 5.043 charge points at 790 locations (Tesla Inc., 2019). Major reason behind is showing to the widest-possible public the company`s clear commitment to electric mobility and understanding the sales push for electric vehicles linked to charging infrastructure. Tesla achieved an integration of their charging infrastructure into their unique customer proposition and the company has created a robust charging infrastructure network (Markkula et al., 2013,). Due to this, it could be an important contribution to the private sector charging infrastructure industry. TESLA especially emphasizes that chargers are also a major selling point for the company's cars, meaning that the Supercharger network is not intended to be profitable; it is just to cover the costs (UCL, 2019).

An important development for public-charging concepts (BEV) is the rapid progress concerning load management (Aurora, 2018). Load management is about distributing the available charging power flexibly based on demand with a smart charging approach. Assuring financial benefits in case of peak shaving is a most promising option. Via an incentive system, charging beyond rush-hours could be promoted in order to avoid load peaks and to keep grid usage costs low. With intelligent charging instead of “static” charging, one-time and regular electricity costs could be reduced significantly by approximately 30% to 70%. In practice, load management is achieved by networking the charging stations. However, all these regulations and the corresponding incentives have not been finally introduced. Further regularities are to be implemented to underline the endeavours for stabilizing the energy transition (Aurora, 2018, p. 43). In addition, prediction of the prevailing battery technologies remains difficult. Referring to IRENA (2019, p. 75), “nevertheless, it is envisaged that there will be increases in the energy density of batteries, which will lead to greater battery capacity and to improvements for energy that could be stored or released in line with the needs of the electricity system”.

Over and above there is an emerge of completely new upsides and complementary business models for charging hubs. Positive effects could be stationary energy storage. The revised “Energy Industry Act” (EnWG) with the updated section 14a is the basis for the possibility for charging stations to act as flexibility providers in the energy markets. During low use times, it may be possible to utilize the storage to provide ancillary services for grid operation (Aurora, 2018, p. 6). However, Burnham also keeps in mind that the real benefits very much depend on location and services needed, because availability for possible fast charging events also has to be retained. In parallel, there is the possibility that other storage systems could meet these demands while being integrated into other grid and microgrid-settings, often in conjunction with renewable energy generation assets (Burnham et al., 2017).

Nevertheless, Ligen, Vrubel and Girault (2018) clearly state in recent publications, that grid-scale equipment such as mega-batteries can heavily impact the costs of recharging stations, by effective coupling of electric mobility needs with intermittent renewable electricity sources. Besides these developments over time, technical development and regulatory reform could make new revenue streams available to charging stations, especially those with “Vehicle-to-Grid”-technology, as they provide different forms of flexibility to local and national networks (Aurora, 2018). These authors also points out that business cases could be further improved using co-located solar generation for suitable sites.

Several publications have already explored the cost of public charging stations. These publications analyse cost components of the installation and operation of charging infrastructure (Wildemann, 2018). They also present methods for a first profitability analysis of charging stations, additionally taking into account indirect benefits such as marketing and customer services. In this context, the mere provision of electricity or hydrogen via charging points will hardly be a viable business in the near future. According to Wildemann (2018), the operation of charging points is only an important component of extended business models. Profitable business models can hardly be achieved in the medium term in conjunction with other service components (Wildemann, 2018). In addition, the consulting company Deloitte, clearly states that besides the provision of charging infrastructure as well additional indirect earnings could be considered in an overall, long-term business case (Deloitte, 2020).

In relation to the World Economic Forum, “there is no common or clear vision for how the design and deployment of the required infrastructure would be affected by changes in mobility patterns, vehicle technology or energy systems” (WEF, 2018, p. 7). New mobility trends, especially, and related new solutions have not been evaluated comprehensively so far with regard to their positive influence on business cases for future charging stations. For Dijk et al., (2013), the main three developments are the expansion of mobility operators and service providers; as well the systems of inter-modality and the new sharing economy. Due to this, the sustainable success of the charging station business case depends, in general, on changes in mobility patterns and offering of new service solutions. This research gap will, therefore, be further analysed within this scientific project. The aim of this project is to finance future charging stations via an integrated, sustainable business model.

Garcia is one of the first authors to clearly describe the correlation in the so-called “eMaaS-ecosystems”. Major elements of this ecosystem are Mobility-as-a-Service (MaaS, e.g. multi-modal, on demand), Electric-Mobility-Systems (EMS, e.g. charging or electric technologies) and Shared-Electric–Mobility-Services (SEMS, e.g. Peer-to-Peer, non-membership based) (García et al., 2019).

The focus of this interdependent ecosystem is assuring the mobility of users from A to B in a seamless and eco-friendly way. Garcia states that in this ecosystem construct, multiple forms of electric transportation are integrated, including public transport and shared electric mobility services.

The main target to consider is the mutual influence and achievement of a single mobility service. This service is provided by a single customer-centred interface, which includes a wide range of electric mobility technologies and charging infrastructure. For Garcia, “such architecture must ensure the smooth integration of all elements in the ecosystem and should allow for effective interaction between them” (García et al., 2019, p 3ff). Some eMaaS-architectures (figure 20) have already been used in practice and have become the first successful approaches (García et al., 2019, 2ff). Nonetheless, according to this article, one limitation is that it has not yet been evaluated; this will be subject of short-term future research (García et al., 2019). The current state of the art regarding MaaS-ecosystems and systems architectures is limited, although some examples can be found in the literature, which are useful conceptual references for the comprehension of the MaaS-model and its positive interdependences. This positive economic dependence at least should also lead to a sustainable business model of charging hubs (García et al., 2019); enabled by new mobility trends and behaviours.

Figure 20 | Electric Mobility as a Service (eMaaS) ecosystem (García et al., 2019, p.7)

Based on this background and linking explanations, the following research question arise.

The answers should cover the research gap, which must be researched systematically in the course of further investigations.

The main research question is about “how parameters and key criteria for an optimised business model for electrical charging hubs should be designed”.

The related research aim is the achievement of a sustainable business model for private charging operators. To be determined, if the sustainability of this business model could be achieved by new mobility trends and by the new role of the public charging hub – being a “mobility hub and transfer point”.

3.5.2 What is the intended contribution to theory and practice via this research project?

Harrison & Thiel (2017) and as well Lucien (2020) described the positive effects of charging infrastructure on the European electric vehicle market share and sales figures. While defining this calculation model, various powertrain types, providers of charging solutions, policy makers and EV-drivers have been integrated. According to Hall and Lutsey (2017a) via addressing a broad population and assuring several feedback loops, realistic decision-making patterns could be captured.
This assessment approach evaluated also the profitability of charging infrastructure, while considering alternative scenarios and as well subsidies and governmental targets. The authors explored whether "the private market could profitably support 95% of public charging stations, up to a ratio of 25 electric vehicles per charge point" (Harrison & Thiel, 2017; Lucien, 2020, p.12ff). This research project, therefore, confirms that under certain premises a sustainable business case would be possible, when certain relevant parameters are fulfilled.

Garcia also describes mobility as a service-framework (García et al., 2019). While the relevance of services has increased over recent decades, planning and calculation for services is often disregarded. Instead of following a theoretically clear process, services are often offered to the customer unsystematically. Via this framework, a theoretical-based concept for process-oriented planning and calculation of services is, therefore, to be used in order to assure the required sustainable business model for charging infrastructure, enabled by new mobility trends and behaviours. How successful a related business model may be largely depends on activities in advance. Systematic research into business models for charging infrastructure is only in its infancy. Comprehensive methods, approaches, management concepts and business models are to be designed and controlled effectively (Markvica et al, 2016). In this context, service engineering is an essential success factor for related charging providers and -operators (Bullinger, 2004).
However, business model diversification remains a rather underexplored phenomenon (Aversa & Haefliger, 2016). The complexity of operating interrelated business models and their underlying mechanisms is of particular interest with regards to this new sharing economy and the new multi-modal mobility (Münzel et al., 2017). But there is only some information available on how sharing economy firms can benefit from a combination of different business models. Recently in Germany, public discussions have started about the new business models developed with the sharing economy. The mobility provider Uber, for instance gained sad notoriety in Germany for its legal disputes (Herwig, 2017) until it finally had to discontinue its services (Herwig, 2017).

In the context of the theoretical frameworks in this chapter, the background of electric mobility, charging and business case sustainability is discussed. Critical reflection on new mobility trends and behaviours is also integrated.

The possibilities for developing a sustainable filling station business, based on the keystone of future mobility are definitely manifold. Consequently, the aim of this thesis is a sustainable business case for an electrical mobility station, as well filtering out the influences of future mobility trends.

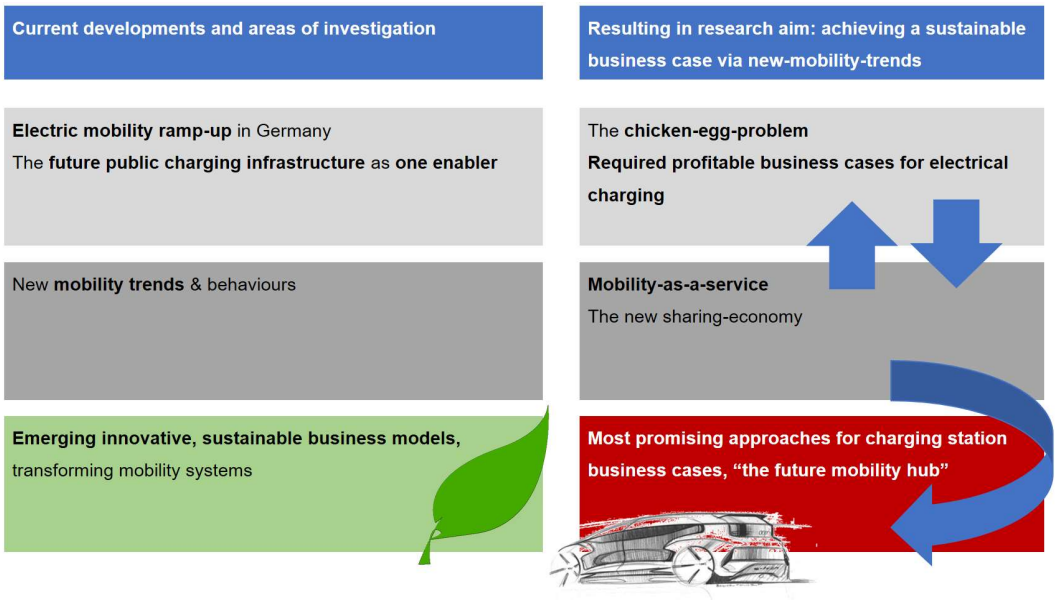
The assertion is that there are most promising approaches for filling station business cases, based on the determined mobility behaviour with embracing trends like “mobility-as-a-service, multi-modal mobility, one-stop-solutions, on-demand- or sharing mobility solutions”.

An adoption of new sustainable mobility solutions will first come to effect in the cities. Here, the importance of the private car will decline faster than in rural areas.

This framework has to be understood in order to apply and analyse the evolving research question (see figure 4 & 5). Figure 21 is a reference for the following empirical research. This illustration is completing the full perspective on this research project, via visualising the three main dimensions of the research gap. The related theory areas are presented first, to give the reader enough knowledge, before going into further evaluation and analysis in chapters 4 and 5. Thus, chapter 2 and 3 are describing current developments and areas of investigation. This literature review is clearly leading to an understanding for the chicken-egg-problem, the necessity for sustainable business models and current investigations of new mobility trends and behaviours. Hence, a critical literature review is deducted, shaping the research aim of achieving excellent approaches for charging stations business cases and the future mobility hub.

The underlying research aim is therefore to be summarized: Attaining a sustainable charging business case via new mobility trends and behaviours.

Figure 21 | Area of research and the three central dimensions of the research gap (own illustration)



CHAPTER 4 | RESEARCH PHILOSOPHY, METHODOLOGY, STUDY DESIGN

The research philosophical stance, the methodology and methods and the overall research design applied in this research project, will be thoroughly explained, both in theory and in its practical application for this case. Critical discussions of the methods in terms of reliability and validity are also integrated in this chapter.

4.1 Research philosophy overview and critical evaluation of research philosophical stance

With reference to Atkinson et al. (2001), in general the researchers themselves bring their own perceptions, values, beliefs and experiences related to the area of investigation and thus mainly influence the philosophical stance (Denzin & Lincoln, 2011). Research paradigm or a philosophical stance always refers to this set of beliefs and feelings about the world and how it should be explored and studied (Alvesson & Sköldberg 2000). In parallel, Holloway argues that the philosophical framework is a worldview and a belief system based on a particular ontology and epistemology, and therefore is widely accepted by a scientific community (Holloway & Todres, 2003).

Thomas Kuhn (1962) summarized the research paradigms in his book, "The structure of scientific revolutions" and described the various research paradigms, which emerged and have further evolved over the years. Based on Thomas Kuhn, and as an important basis for further research considerations, the following table (figure 22) is included as part of this doctoral thesis. This overview is used as a starting point for overall scientific thoughts and is respectively referenced in terms of the whole research project. In parallel, there are also integrated further reflections of Guba & Lincoln (1994) and Pallas (2001). Thus, especially intention of figure 22 and part II., is to consider the various epistemological approaches in relation to the chosen one and alternative realities. Further explanations are influenced by this summary.

Figure 22 | part I. | Research as continuum and overview of research paradigms
(illustration, adapted by authors Kuhn, 1962; Guba & Lincoln, 1994; Carson et al., 2001; Pallas, 2001)

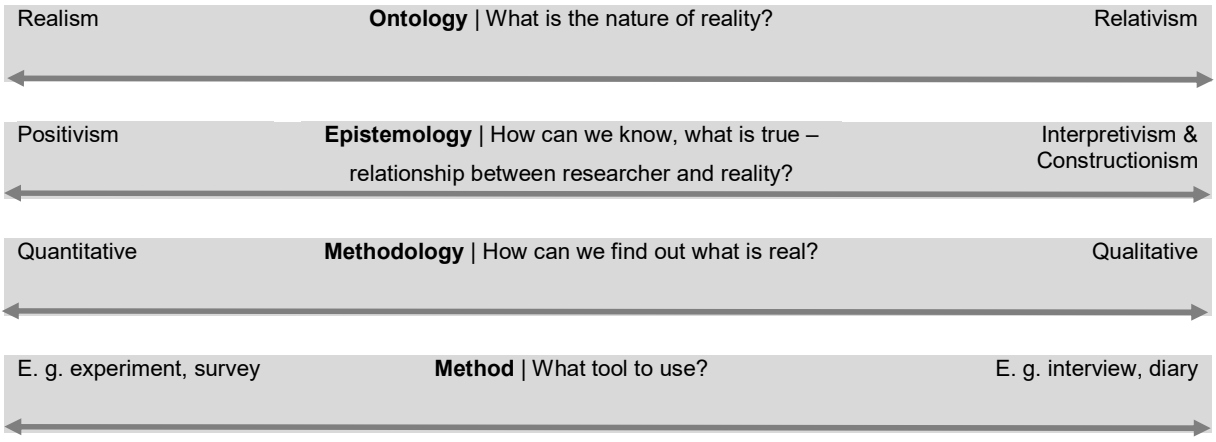


Figure 22 | part II. | Research as continuum and overview of research paradigms
(illustration, adapted by authors Kuhn, 1962; Guba & Lincoln, 1994; Carson et al., 2001; Pallas, 2001)

	Ontology	Epistemology	Methodology	Forms of knowledge produced
Positivism ➔ "Verify"	Reality is out there to be studied, captured & understood, findings are truth and realism **Objectivist- reality is objective and singular, apart from the researcher**	The only knowledge is scientific, knowledge which is truth, reality is apprehensible	Quantitative, primarily experimental, quasi-experimental	Verifies hypothesis as facts or laws
Post-Positivism ➔ "Predict and control"	**Singular reality exists but is never fully apprehended, only approximated, findings probably true, transcendental realism** Modified Objectivist	Approximations of reality, researcher is a data collection instrument Findings approximate truth, reality is never fully apprehended	Rigorously defined qualitative methods, frequency counts, low-level statistics and thus also quantitative	Generalizations, descriptions, patterns, various perspectives, not falsified hypothesis that are probable facts or laws
Interpretivism ➔ "Understand & interpret"	**Multiple realities are constructed - no single external reality** Subjective relativism	Co-created multiple realities and truths, Knowledge as a human construction, researcher and participant co-construct understandings	Naturalistic, qualitative methods, and/or supplemented by quantitative measures	Case studies, narratives, interpretations, reconstructions
Critical Theory ➔ "Critic, transform, emancipate"	**There is a reality, that is apprehendable,** created and shaped by social, political, cultural, economic, ethnic and gender-based forces that have been reified or crystallized over time into social structures that are taken to be natural or real. Historical, virtual realism shaped by outside forces, material subjectivity	Findings are based on values, local examples of truth Knowledge as subjective and political, researchers` values frame inquiry	Usually qualitative measures, but also quantitative measures	Value mediated critiques that challenge existing power structures and promote resistance – structural / historical insights Historical situatedness, generalization by similarity
Constructivism ➔ "Understanding, reconstruction"	**Reality is constructed, subjective, multiple, relative. Constructions are not more or less true, only more or less informed** Reality is constructed from human subjective minds and perceptions	Understanding, more informed and sophisticated reconstructions, vicarious experiences, Trustworthiness and authenticity	Usually qualitative	Interviews, observations, visual data analysis

According to Grix (2004, p. 68) “research is best done by setting out clearly the relationship between what a researcher thinks can be researched (reality and ontological position), linking it to what we can know about it (epistemological position) and how to go about acquiring it (methodological approach)”. Before beginning a research project, there is a clear “necessity to comprehend the impact of the ontological position on what and how someone in general decides to study” (Grix, 2004, p. 68). As a consequence, the related reality definition represents a set of common beliefs and agreements shaping how research questions are going to be addressed (Kuhn, 1962 cited in Guba & Lincoln, 1994). For this reason, the various approaches are summarized above in relation to their reality assumptions (figure 22).

Ontology is related to the researchers assumptions about reality, i.e., whether reality is objective or subjective (existing in our minds). Figure 22 illustrates, that qualitative research assumes multiple truths while quantitative research assumes a single truth. For the quantitative researcher reality is objective and exist separately to the researcher and the same conclusions will repeatedly be derived.

The qualitative researcher embraces multiple realities, meaning that persons understand reality in different ways that reflect individual perspectives. As an alternative, there are truths to be discovered, and these truths are bound by the time, the context, and the individuals who believe them. Often, shared beliefs or shared realities are what constitute truth (Carson et al., 2001; Pallas, 2001). Understanding, broad patterns and interpretation are to be focused. The influence from both science and personal experience is thus accepted. This would allow researchers insight into the people themselves, being sure to appreciate and take seriously how people perceive reality (Kuhn, 1962; Guba & Lincoln, 1994; Carson et al., 2001; Pallas, 2001).

The chosen post-positivistic research paradigm encompasses one social reality, which has enough stability and patterning to be known (Creswell, 2014). This reality exists but is never fully apprehended, only approximated. Research assumes that this social reality is conceived as coherent, whole and singular. Post-positivist researchers view inquiry as a series of logically related steps and make claims of knowledge based on objectivity, standardization, deductive reasoning, and control within the research process (Creswell, 2014). If post-positivist and constructivist research are located on a paradigm continuum, they will be anchored on its two opposite ends (Pallas, 2001) (figure 22). Therefore, also part II. of figure 22 is summarizing positive aspects and critical points of all research approaches and reality perspectives. This critical evaluation of the broad variety of research approaches underlines the decision for the chosen one (figure 22).

Despite the growth in constructivist approaches, business model research has been dominated by objectivist ontology. There is an upcoming of literature represented by radical theorists, who recommend and utilised various critical and constructivist approaches. These types of business model research are generally not linked to explanation, but rather with interpretation, and are based on the idea that business model information is also subjective to a certain extent.

Differing views about the nature of reality (ontology) affect the relationship between the researcher and reality and whether reality, is supposed to be discoverable from an objectivist or subjectivist standpoint (epistemology) (Kuhn, 1962). A paradigm, that could draw on the strengths of, and reconcile to some measure both schools of thought, could contribute a great deal towards harmonising research attempts.

Laughlin (2019) focus is nearly similar, suggesting a different solution.
Laughlin is clearly showing a middle-range perspective in scope his overall research activities about business modelling (Laughlin, 2019). Both positivist and constructivist approaches are valuable in business model research, although each has weaknesses.
This perspective emphasizes, that positive research paradigm could determine particular forms of explanations for business modelling. In parallel valid arguments arise, that a multiplicity of other structures, variables, behaviours or influences are also important. Finally, generalisations are often necessary for shaping or improving practice and policy (Laughlin, 2019).

From an ontological perspective, this research project should access the perspectives on electric mobility and charging. An understanding about current challenges of public electrical charging has to be achieved. A volatile framework is shaping the present and future challenges. Finding out the reality of charging- and mobility service providers on their way towards a sustainable business case and how they have been experiencing this journey. The multi-truth approach can especially be justified do to the character of a very emerging area of research “electric mobility” with miscellaneous stakeholders and various truths – a governmental, business-related, science-related and the emerging start-up perspective. Another limitation of pure quantitative research is that the positivism cannot account for how the social reality regarding such a ground-breaking topic “electric mobility” is shaped and maintained, or how people interpret their related actions and others (Bardt et al., 2019). Otherwise, it has not been possible to take information deeply; rather, it could only give the overall picture of the variables (Bardt et al., 2019).

Considering this research question about the future-charging hub and the introductionary ontological- and epistemological description above, the corresponding decision was made to follow the research philosophy “post-positivism”. This is a very suitable research approach in order to evaluate the topic from a scientific perspective and to find innovative answers to the overall research gap “sustainable business modelling”. Within the context of this research project, the underlying scientific paradigm should act as a lens that the researcher uses to view the world. Therefore, it reflects the specific worldview of the researcher and the means to suitably approach the particular research question about new mobility trends that also influence sustainable business modelling (Guba & Lincoln, 1994) in terms of charging hubs.
Against this background, post-positivism is used in this study for several detailed reasons. Firstly, it integrates quantitative research aspects, where the researcher remains objective and separate from the area of investigation. Experiences can, therefore, be partially reduced to objective measurement within e.g. standardized questionnaires and surveys
Positivism and related quantitative research clearly emphasize the existence of a true and objective reality (see also figure 22) that can be studied by using methods and principles of natural sciences (Healy & Perry, 2000; Krauss, 2005). According to Bryman and Bell, (2011) positivism clearly determines that objective knowledge of an external world can only be achieved by careful systematic and scientific procedures. Creswell (2014) and Hacking (1983) highlight the positivists’ research paradigm, according to which the purpose of science is to observe and measure.

Knowledge of anything beyond is not possible and the key approach of the scientific method is the experiment (Hacking, 1983; Creswell, 2014). However, since the middle of the 20th century the views of science have changed (Kuhn, 1962; Guba & Lincoln, 1994; Pallas, 2001 | see figure 22).
For many researchers perhaps the most important change has been the development from pure positivism towards post-positivism (Hacking, 1983; Creswell, 2014). The newly evolving post-positivists' perspective highlights argues that scientific thinking and working can be compared with our daily lives. Scientific reasoning and common sense reasoning are mainly the same procedure (Hacking, 1983; Creswell, 2014). There is only a difference in degree (Hacking, 1983; Creswell, 2014).
In contrast to the pure positivist approach, post-positivists therefore accept that the natural sciences do not provide the only model for social research (Creswell, 2007). In reaction to this conventional tendency towards quantitative empirical analytic based research, social sciences researchers came up with the idea of a mixed paradigm combining positivism and interpretivism and creating a new paradigm named post-positivism (Kock et al., 2008).
The idea is using the strength of both quantitative and qualitative aspects to analyse these research issues applied to the need for charging infrastructure-business model innovations and corresponding business cases. For instance, the objective measurement approaches should be used to determine the real need for public charging solutions and especially structure, via a quantitative analysis applied to the "range-anxiety | range-envy" argument. According to public opinion, there is a clear need for a public charging infrastructure in Germany, because the average user needs it as a psychological backup (Wirges, 2016). Please also see evidenced explanation for range anxiety and -envy in chapter 2.2.2. Nowadays, people are used to refuelling their vehicles at petrol stations and using them in a long-distance mode. Public opinion that a charging infrastructure must be in place is therefore only logical. After all, there is still a long way to go before market penetration is achieved and users' driving behaviour will change. In this way, the strength of quantitative measuring will notably be used to evaluate this current requirement.

Based on this, the second reason for choosing post-positivism can be derived. The particular target of this research project is to obtain a much better understanding of the charging infrastructure and suitable new business models.
The purpose of this study is not pure testing of theories; it is much more to ascertain if a more complete picture of sustainable business models for public charging infrastructure could be developed. Within the context of this research, the perspectives of various participants are integrated, also resulting in the requirement to explore the perceptions and perspectives of different people, all of whom may have a different version and perception of reality. Positivists and post-positivists believe in the existence of a single reality (figure 22); however, post-positivists claim that reality can never be fully known and efforts to understand reality are limited owing to human beings' sensory and intellectual limitations (Guba & Lincoln, 1994). Therefore, the underlying epistemology is that post-positivists believe that human knowledge is based not on a priori assessments from an objective individual; but rather upon human conjectures (Bergman, 2011 & 2016).

The related epistemological position should be objective, although it is acknowledged that there may be researcher bias. Besides post-positivists work to understand how their axiology, i.e. values and beliefs, may have influenced their research, including through their choice of measures, populations, questions and definitions, as well as through their interpretation and analysis of their work (Robson, 2002).
From a pure post-positivist`s point of view, the subject of study is independent of researchers and knowledge is acquired and proven only via direct observations (Godfrey-Smith, 2010). According to this research philosophy, the role of the independent researcher is to provide material for the development of laws by testing theories (Bryman & Bell, 2007). The focus of post-positivism and the underlying research is prognosis and related explanation. Like positivists, post-positivists also want to be objective, neutral and ensure that the findings fit with the existing knowledge base. However, unlike positivists, they acknowledge and spell out any predispositions that may affect objectivity (Doucet et al., 2010 cited in Schuh, 2012). From an ontological perspective, post-positivists suppose that a reality exists, as positivists do (Kuhn, 1962; Guba & Lincoln, 1994; Pallas, 2001) | see figure 22), although they hold that it can be known only imperfectly (Miller, 2007).
Thus, post-positivists also draw from social constructionism in forming their understanding and definition of reality (Kuhn, 1962, Miller, 2007). In a modern interpretation from a post-positivist`s point of view, this also means that no general conclusion can ever be reached simply by induction from a limited number of examples; therefore hypotheses can only facilitate but never be proven only by numbers.
From there, post-positivism does not aim to reject the scientific, quantitative elements of positivism in the research, rather it emphasizes a proper understanding of the directions and perspectives of any research study from multi-dimensions and multi-methods (Guba & Lincoln, 1994).
Especially for this very new research area, in relation to the upcoming electric mobility trends, it is clearly necessary to generate research information that is not only supported by limited figures and examples. Allowing also in parallel some interpretation and integrating various perspectives is an important prerequisite for a successful research approach and the intended framework definition (Kuhn, 1962; Guba & Lincoln, 1994; Pallas, 2001| see figure 22).

The third reason for the post-positivist approach is also the flexibility in research, gained via an iterative research proceeding. At the Paris climate conference (COP21) in December 2015, 195 countries adopted the first-ever universal, legally binding, global climate deal. The agreement sets out a global action plan to put the world on track to avoid dangerous climate change by limiting global warming to well below 2°C. The “Paris Agreement” is a bridge between today's policies and climate-neutrality before the end of the century; as well meaning an intensive speed-up in research and development in this area and for sure new emerging perceptions for electric mobility and charging infrastructure BMWI (2020).
The respective research perspective is that all observations are theory driven; all research is informed by some theoretical perspective and, hence, undertaken with one set of assumptions or another.
All data sets underdetermine theory; therefore, for any set of data it is possible to suggest more than one model or theory that could explain it. In order to assure a successful electric mobility turnaround, enabled by new charging infrastructure and innovative business models, it clearly requires such a research proceeding. Only by withdrawing acquired knowledge, followed by further investigation, is a successful overall research concept possible as an iterative process.

Besides, Creswell's comparison, positivist believe that the overall focus of science is to uncover the truth. In contrast, a post-positivist believes that the goal of science is to hold steadily to the goal of getting it right about reality, even though this could never be achieved (Creswell, 2007; Frey, 2018).
This modern understanding of science and the research philosophy "post-positivism" suggests, that therefore all scientific knowledge is provisional in the sense that it is open to review in the light of new evidence (Yakov, 2018). According to Hacking, post-positivism recognizes that all observation is fallible and contains errors, and that all theory is revisable (Hacking, 1983). Negative results can always be disproved in terms such as human error, technical failures, or flaws in the theory of the instrument used - so hypotheses are never absolutely proven wrong (Miller, 2007). Against this background, post-positivism is not regarded as separate philosophical tradition.
Creswell considers post-positivism as an extension of positivism, since it clearly represents the thinking after positivism; challenging the traditional attitude of the absolute and objective truth of knowledge in the social sciences. This also means that from a post-positivism perspective, it is not possible to evaluate and understand reality, merely by measurement (Kuhn, 1962; Guba & Lincoln, 1994; Pallas, 2001 | see figure 19). Post-positivists argue that reality can never be fully recognized; only approximated (Plack, 2005; Creswell 2007).

As a fourth, central advantage for using post-positivism, the integrated creative ways of gaining information can be mentioned. Post-positivist research often combines qualitative, as well as quantitative proceedings.
For the development of alternative research strategies, this allows information to be found in unlikely and very creative ways (Schoonenboom & Johnson, 2017). Post-positivism has substantial influence and strength since it presents and formulates knowledge of the social world similarly to science, and applies the same methodologies used in the natural sciences to the social sciences, hence "scientific" evidence can be given.
This can be considered as both; on the one hand, this is a key strength of post-positivism; encouraging social sciences to think much more critically about the status quo and the reaction against positivist epistemology, questioning its methodology (Kuhn, 1962; Guba & Lincoln, 1994; Pallas, 2001 | see figure 22). On the other hand, this could also be a counter-argument, when scientific methodology is not a suitable research method (Schoonenboom & Johnson, 2017).
Post-positivists therefore accept in general that the natural sciences do not provide the only model for social research. Therefore, post-positivist research is much more open with regards to various methodological approaches. The post-positivistic paradigm promotes the triangulation of qualitative and quantitative methods that explores the diversity of facts researchable through various kinds of investigations, but respecting and valuing all findings as the essential components for the development of knowledge (Braun & Clarke, 2006). For the development of alternative research strategies, this allows information to be found in unlikely and very creative ways (Schoonenboom & Johnson, 2017). The field of electric mobility and charging is a highly innovative and new market in which the entire economy has to reorient or reposition itself. This is, from today's perspective, a very ambitious goal and it is linked to numerous challenges and framework conditions that have to be shaped and created.

Having generally said this, there is also a clear necessity to gain information for this research project in very creative ways and use possible alternative research strategies to emphasize the research gap and the related unique aspects in terms of charging business model innovations and new mobility trends.

4.2 Impact of chosen research philosophy on research strategy and design

4.2.1 Study design, choice of research methodology and primary data collection methods

In general, the research strategy and design focus on the functional plan in which a specific research methodology, certain research methods and procedures are linked together in order to ensure that the research purpose is achieved. In particular, Zikmund (2010) stresses that the research problem always significantly influences the methodology, the methods, types of measurement, the sampling, the data collection and the data analysis, which are used for the proposed research. Generally, the research design employs a series of logical decision-making alternatives, which must be selected wisely by the researchers with reference to the objective of the overall research study (Cavana et al., 2001).
The underlying epistemology for this research project could be characterized by emphasizing meanings and the creation of new knowledge, especially considering electric mobility and charging, the emerging mobility trends and newly arising business models. On account of this, the post-positivist stance does not simply aggregate data in order to achieve the aim of overall truth. But it does mean for this research question and the intended business model framework, the complexity of the overall topic is recognized and acquired experiences are to be integrated.

Related business model research is broad rather than specialized and from a post-positivist`s perspective, lots of different elements are to be qualified as research and are a possibility in terms of achieving scientific knowledge. Because of this theory and practice cannot be kept separate when generating research knowledge. From there, Schratz and Walker state that the researcher's motivation and commitment to research are central and crucial to enterprises (Schratz & Walker, 1995). A post-positivist researcher adapts a learning role rather than a testing one (Wildemuth, 1993). Research is conducted among other people, learning with them, rather than conducting research on them (Wolcott, 1990). In post-positivist research, knowledge is constructed through a dialogue. Researchers discuss the issues raised during the interviews, in the questionnaire-approach or during the intended focus group session; all participants' reactions and interpretations of these combined ideas are to be integrated (Wildemuth, 1993). Regarding these epistemological considerations, this research project involves a certain research methodology and structure, used to underpin the work and the previously mentioned methods to collect data. Most notably of the chosen post-positivist research approach, the decision was made to combine qualitative and quantitative research methodology. According to Denzin and Lincoln, post-positivism refers to multiple methods in order to understand as much of reality as possible. In parallel, the verification of theories is emphasized. Traditional evaluation criteria, such as internal validity, are stressed by using qualitative procedures and structured analysis (Denzin & Lincoln 2011). However, they believe in an objective reality; rather than focusing on certainty and absolute truth, the post-positivist will focus on confidence.

Hence post-positivism, in parallel, employs more subjective, qualitative measures for the collection of information. Qualitative data collection procedures are used, especially in this research project, to understand experiences and beliefs of integrated field experts. Considering a purely positivist standpoint with related quantitative approaches, this has some weaknesses, particularly with regards to this very new topic. Quantitative research is often perceived to be weak in understanding the context and to integrate human interests. On the other hand, qualitative research is seen as deficient, because of the personal interpretations and the involvement of the researcher that may lead to bias (Creswell 2014). But also referring to some doubts (Schoonenboom & Johnson, 2017), Schoonenboom and Johnson also emphasizes that the underlying research enables the usage of very creative methods (Zikmund, 2010).
Creative research approaches are chosen to achieve very rich data and enable the researcher to dig into this new research area of charging infrastructure, emerging mobility trends and innovative business models. According to Domegan and Fleming (2007, p. 53), “qualitative research aims to explore and to discover issues about the problem on hand, because very little is known about the problem. There is frequently uncertainty about dimensions and characteristics of problem. It uses soft data and obtains rich data.”

Therefore, especially in order to have both possibilities – qualitative and quantitative research tools – this decision was made for the research philosophy post-positivism. Only by combining qualitative and quantitative approaches and by using mixed methods, the possibility arises to draw from the strength of both and to highlight the unique aspect of this topic. Through this integrated view of all partial areas, this thesis differentiates itself from all existing projects, which are based on a more isolated view to the individual areas.
The two disciplines differ also as following, qualitative research is inductive and quantitative research is deductive. For this research project and the more qualitative research proceeding, a hypothesis is not needed to start working on this research topic. Inductive data analysis is resulting in a much better understanding of the interaction of mutually shaping influences and interacting realities (Guba & Lincoln, 1994). Every researcher and the integrated experts in the respective field of study have diverse attitudes and perspectives or experiences.
Due to these diverse perspectives and values systems, their influence on the interpretation of reality and the outcome of a study cannot be predicted. This requires an approach to evolve rather than having a complete design in the beginning of the study.
Qualitative research is most appropriate when the researcher wants to become more familiar with the phenomenon of interest, to achieve a deep understanding of how people think about a topic and to describe in great detail the perspectives of the research participants. An empirical investigation will be undertaken for this study, using qualitative and quantitative methods to obtain data in parallel. Hence, mixed method research is intended for this thesis; meaning a combination of interviews and a survey questionnaire to summarize and confirm the major research pillars of that thesis. The information obtained from the empirical research of a study serves to support and provide evidence for the stated problem and the accompanying research questions (Kötter, 2008).

This combination of in-depth interviews and questionnaire to summarize the basic data set is followed by a practitioner's "sense check" in the context of a closing focus group session. Within this final focus group session, topic-specific experts in the field of study, give input on their specialized expertise and are closely involved in the design of business models. Hence, a mixed method approach integrates a focus group session to summarize and confirm the major research issues of that thesis.
In the focus group and interview-session, the face validity of the participants is based on their very deep expertise and practical judgments. This will be especially monitored in scope of the final "sense check" by practitioners and will be used as main advantage of these two primary data collection methods.

Also based on the scope and complexity of the research topic, a decision was made for a mixed methods design to conduct this research. This mixed method approach will be used consciously, in order to determine the needs and competencies required by prerequisites for successful business models. By looking at multiple perspectives on that topic, the intention is to make some kind of generalization on what something is like from an insider's perspective and to strengthen the accuracy, trustworthiness and validity of the research (Denzin & Lincoln, 2011). Mixed Methods should lead to a full picture of charging solutions business models and should enable a reconfirmation of research conclusions. Several strategies for mixing qualitative and quantitative methods are available. For this current study, a mixing strategy will be used, meaning that the quantitative data will be linked in order to build or develop the subsequent qualitative data. More specifically, the data will be connected in a way, which ensures that the quantitative results are used in collaboration with the interviews and the survey to facilitate the design of a qualitative measurement instrument – the focus group session. In this way, it facilitates the triangulation of data.

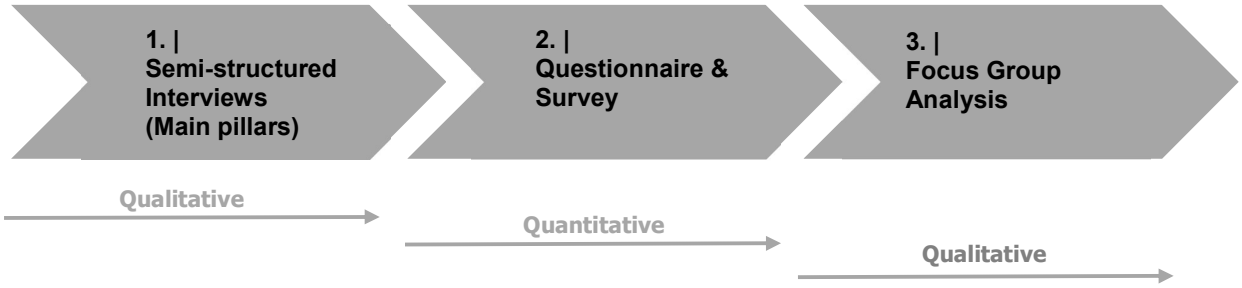
Answering the research question involved the development of a business model to enable charging solutions. While the research includes inquiries about the context of architectural drivers defining and shaping this new market; and what dynamic resources are critical to capture this potential from the perspective of a German global player; the main focus is on related business, and operator models, which enable an intensified market launch of electric mobility charging, overcoming the aforementioned "chicken-egg-problem". The research question also includes future analysis, on the latest research on innovation strategies, to determine what shapes innovation strategies in the context of this radical change in the electric mobility sector – the technological dimension – as well as from an economic / business design perspective. A holistic approach to these innovation strategies providing new products to new markets (architectural innovation) is inevitable (Pisano, 2015). Via the survey, and focus group study approaches, the intention is to reach a starting point that will lead to an answer to the main question and to design an optimised business model framework to accelerate a further market penetration of public charging solutions. From the perspective of a German global player and charging infrastructure provider, this new market potential could only be realized when assuring sustainable business models. Only via the intended framework, the electrical car drivers are able to use at short notice the full potential of these innovative, complex-charging solutions.

To summarize, from a post-positivist perspective, the main interest should be the overall understanding of the research, especially as it evolves during the complete research process. Hence, post-positivists believe that positivist research is, in many ways, not suitable for many forms of social research (Schoonenboom & Johnson, 2017, p. 107-131) and particularly for such an “evolving” research into a very new area of science: “electric mobility”. Thus, the main reason for choosing “post-positivism” and the underlying mixed-methods approach is that the intention is to gain a full understanding and an overall research picture with meaningful conclusions.

Via the intended insider perspective, the idea is to supplement the available research and to gain new knowledge about this very new field of research. This would allow some interpretation that would serve as an important prerequisite, besides insight into various relationships.

4.2.2 Usage of methods, pilot study experiences and data equivalence

Figure 23 | Data collection methods (own illustration)



- **The interview session – resulting in narrowing down the topic**
- **The online survey – expanding the understanding via a widely spread expert survey**
- **The focus group session – a concluding sense check by practitioners**

Buckley and Chiang define research methodology and assigned measures as “a strategy or architectural design by which the researcher maps out an approach to problem-finding or problem-solving” (Buckley, 1976). In order to underline a mixed methods approach with regards to the primary data collection and problem-finding, a well-considered set of qualitative and quantitative methods has been chosen. To capture diverse opinions and views, qualitative findings need to be supplemented with quantitative results. Therefore, these research methodologies are considered to be complementary to each other (Corbin & Strauss, 2008).
These mixed methods (figure 23) will be quantitative and qualitative, and reflect the intended overall research philosophy “post-positivism”. The different techniques should contribute something unique and collect various data; not only repeating the same information (Bergman, 2011).

The clear intention for this research project is to use the strength of both attempts (Bergman, 2011).
Mixing qualitative and quantitative measures will first of all be undertaken during data collection. It is the clear intent to start with the interview session and to use this acquired information to design the following survey. Of course, this will be enriched, when enquiring information, but also some aspects will be repeated for a second confirmation.
Many authors are assert that this is the best “cycle of enquiry” – following the sequence by applying research methods “qualitative – quantitative – qualitative” Creswell (2014). Creswell (2014) makes reference to studies, which use one method after the other “sequential studies”; meaning the use of two or more methods, one after the other, sequentially.
In parallel, mixing methods in the context of this study means collecting information from different groups of people; that is to say collecting various samples for each step (interview, survey and focus group) coming from the same population. The third evidence for the underlying mixed methods approach is, of course, the intended use of qualitative and quantitative data analysis techniques.

In the appendix the data collection and experiences from the pilot study are summarized with their main aspects and key learnings. These key learnings were also set out and integrated in the following chapters. The related analysis and conclusions are presented in a separate chapter | 5.1 ff.
The idea of a pilot study was conducted because of several reasons. One major point is assuring a pre-check for integrating all relevant subgroups of the intended testing population in a pilot field test. The second key point is to evaluate in advance of the complete primary data collection, the appropriateness and possibility of deriving suitable interpretations. The here developed interview questionnaire and the online survey questionnaire are listed in the appendix. Finally, all explanations about the data collection process are integrated. All relevant details are conceptually described in the appendix and directly address the following guiding questions (figure 24):

Figure 24 | Used methods, description, and key learnings (own illustration, see appendix with more details about the primary data collection process)

Semi-structured interviews	• Why semi-structured interviews at the very beginning? • What are the interview guidelines and the interview processes? • What are the key-learnings from interviews?
Survey	• Why is a survey based on expert interviews? • What are the survey guidelines and the survey processes? • What are the key-learnings from the survey?
Focus group	• Why is a focus group session at the end? • What are the focus group guidelines and the focus group process? • What are the key-learnings from the focus group?

4.2.3 Sampling strategy

The experts for the interviews are chosen from available business contacts and the first impression of their highly valuable contribution. There is no selection by chance. In line with scientific literature, this procedure is also known as “expert sampling (5 interview participants)”. This sampling technique integrates a sample of experts with known experience in the research area “electric mobility, charging and business modelling” (Buckley, 1976). The decision for that purposive sampling strategy was taken in order to dig quickly into this very new topic and it was also accompanied with many controversial discussions in business, politics and society. The idea is to use the chosen expert panel to back the main research pillars, which are in parallel derived from literature (Kohli, 1978).
This first sampling should also be a basis for pre-testing the ideas of sampling in the context of the interview session, in line with the focus group approach. Providing evidence for the chosen “panel of experts” is the main target.

The focus group sample or experts will, of course, not be the same in comparison to the first interview session; rather it is also based on their acknowledged experience and insight into that field or topic in which the 12 participants are asked to examine the modal definitions and to comment on the appropriateness and validity (Oakley, 1998). The reason behind this decision is especially to use the advantages of the fruitful focus group discussions and emerging aspects for an additional validation check. According to the literature on research methods and focus groups, focus groups are, in general, not based on probability or random samples in terms of defining the population. Focus groups are based on convenience sampling in order to obtain an optimal understanding of the research topic and related deeper knowledge. Therefore, all participants are selected; they were easy to contact or to reach.

Via the combination of interviews and a focus group, various perspectives on a given topic and thus data saturation can be achieved. By drawing from several participants and two different research methods, individual perspectives and a group perspective can be explored in parallel. Via this strategy, a suitable amount of data should be collected and data saturation with repeating and confirming research results is assured.

The survey population has a suitable population-size that allows a well-conducted survey to be conducted with an accuracy data collection. Fifty experts where chosen and, due to the selective choice, the response rate was very high (48 responses). When dealing with a reduced population, it is on the other hand extremely important that the sample matches the population with regards to observable characteristics; meaning assuring a consistency with the results we would have achieved if we had collected data on the entire population (Bryman & Bell, 2007, Kötter, 2008). Additionally, it was decided to choose a non-probability sample technique, “snowballing sampling,” also called “respondent driven sampling”. This was chosen because it is a very new research area and the sample characteristics are rare, which makes it extremely difficult to locate a sufficient number of respondents, for example, by random sampling. It allows a study to be undertaken where otherwise it might be impossible to conduct because of a lack of participants (Kötter, 2008).

The idea of a snowballing sampling approach is to rely on references and recommendations from initial respondents in order to generate further respondents. The method was especially made for “exponential discriminative snowball sampling”. Subjects give multiple referrals; however, only one new subject is recruited among them. The choice of a new subject is finally guided by the aim and objectives of the study (Kötter, 2008). Thus, snowball sampling is especially useful when trying to reach populations that are hard to find. Besides successfully approaching this very new research topic with only some available experts, this technique reduces costs. During the data analysis it is extremely important to monitor the possible risk of integrating bias, as this technique itself comprises the likelihood that the sample will not be representative enough of the population (Bryman & Bell, 2007). Other researchers also highlight that the sampling error might not be determined, and therefore there would be a failure to derive certain conclusions for the overall population. However, other statisticians indicate the advantage of a possible discovery of unknown characteristics of the population or reveal hidden populations (Bryman & Bell, 2007).

In many references, there is no specific explanation about sampling techniques that can be used with regards to the intended survey scale. Usually, they only suggest a small number of samples for scale validation.

One of the simplest and most widely used scale types is the Likert scale (Likert, 1932; Babbie, 2005). Therefore in this survey questionnaire, a Linkert scale with 7 items is used. For instance, Nunnally (1978) suggested that a ratio of 5-10 participants per item is sufficient. Thus, the 50 participants targeted in the online survey adequately represent a basic population concerning the Linkert scale. The main reason for choosing the Linkert scale and non-random sampling is that non-random sampling is because the sample that will maximize the variance, is selected during the scale development phase.
Statistical practitioners confirmed that if undertaken in an appropriate way, non-probability sampling could produce the same high-quality data. Most surveys are aiming for the integration of a very specific population (Kötter, 2008). These surveys have normally no need for the same diversity and representation provided by probability sampling. Non-probability sampling approaches are usually faster and cheaper, because of higher motivated sample members in comparison to people who are randomly contacted for a research study (Kötter, 2008).

The final information about the primary data analysis and results are listed in chapter 5. In the following chapter, further details about the basic population and the sampling results are shown.

4.2.4 Data management process, data analysis and operationalization

The choice of methods, in general, involves reflections on how to analyse the database obtained, the conclusions intended to be derived with regards to the main research question, and the chosen post-positivism research approach. These techniques can be applied as much to consider meanings and the participants` experiences as they can be used to explore how these experiences, realities and meanings might be informed by discourses, and assumptions or ideas, which exist in business (Bryman & Bell, 2007).
Hence, for evaluating the interviews, the qualitative method of thematic content analysis is taken (Yauch & Steudel, 2002). The aim is to produce a systematic recording of the themes and issues addressed in the interview sessions and to link the themes together under a reasonably category system. Once qualitative data have been coded, the data should behave like a multiple response question, allowing additional analysis to be undertaken if necessary (Howe, 1988).
The researcher should attempt to offset the own bias and to avoid subjectivity in order to make sense of the data. A chosen check for validity is e.g. that of returning to some of the people interviewed and asking them to read the transcripts of the session and to offer their opinion regarding the main points that emerged from the discussion (Crowther & Lancaster, 2008). The final overview should be a framework showing all major issues emerged in the semi-structured interviews. This evaluation is purely qualitative and therefore the main themes from the interview sessions have not been quantified, they are substantiated by verbatim. The examination of verbatim responses will be textually integrated in the thesis, in order to facilitate or contradict the scientific reasoning and to be the main input for the survey design. The major issues are supposed to come up repeatedly. The related inductive approach involves allowing the data to determine the themes. Finally, the conclusions explain the main takeaways and show how the analysis provides input to the overall research question.

Thematic content analysis was chosen to provide a rich and detailed, yet complex, account of the first data (King, 2004; Braun & Clarke, 2006). According to King the examination of the perspectives of different research participants, highlighting similarities and differences and generating unanticipated insights, is highly important at the very beginning of the research process (King, 2004). Hence, thematic content analysis is used for identifying and developing the major themes related to electric mobility and charging.
In chapter 5 the results of the thematic content analysis, supported by an internal IT-tool are summarized.

The web survey and the survey tool software are an excellent method to gain feedback from a target group and to illustrate that in parallel via several statistical features.
“Here factor analysis is used for data exploration to reveal patterns of interrelationships among variables that are not readily apparent, for confirmation of hypotheses and for reducing the number of variables to a manageable level. In situations involving many different observations concerning the same participant or groups of participants, factor analysis can be used to determine whether it is possible that some of these observations are a result of just a few underlying factors. That is, the correlation among many dependent variables may be explained by some underlying factor or factors (Müller & Thoring, 2012).
The clear prerequisite of the research design is to collect sufficient raw data in order to be able to conduct a factor analysis and to categorize the questions into the main clusters, hence a “clear enabler for electric mobility”, “sustainability and usability of the business model”, “transfer from other industries / branches” and “influence of new mobility trends”. While doing this with the final research data, other data clusters could emerge. Within research theory, the experts recommend a minimum of 50 participants in order to employ a successful factor analysis (Müller & Thoring, 2012); therefore, for this research 50 participants have been taken. With the Linkert scale the intention of this research project is to capture the respondents’ opinion of the online survey. These are items from which a respondent chooses an option from a range of values | 1-7.
The respondents are asked to evaluate the survey questions using a 7-point scale, with the following anchors 1 = strongly disagree or least important and 7 = strongly agree or very important.
The responses are directly transferred to a file, checked for redundancies and converted afterwards for further statistical evaluation.
This Likert scale is commonly used in survey research. It is often employed to measure the attitudes of respondents, asking them to what extent they agree or disagree with a particular question or statement. Data from a survey using a Likert scale may seem easy to analyse, but there are important issues to be considered by a data analyst. In addition to considering the main clusters mentioned above, it is hoped that an answer will emerge available to get an overview of the major patterns in the data; for instance an identification of groups of inter-related variables, to see how they are related to each other. Patterns are e.g. clear priorities and weighted scores for benchmark estimations (Crowther & Lancaster, 2008). Some scholars still debating whether the Likert scale can be treated as an interval scale and, hence, adaptable to parametric statistics e.g. Lubke and Muthén (2005).

However, some argue the contrary i.e. the Likert scale should use non-parametric statistics e.g. Jamieson (2004). Crowther and Lancaster (2008) opine that the assumptions regarding the measurement level of the data and the corresponding analysis to be used, affect the conclusions. One group maintains that as ordered categories, the intervals between the scale values are not equal. Any mean, correlation, or other numerical operation applied to them is, hence, invalid. Non-parametric | non-continuous statistics should be used on Likert scale data (i.e. Jamieson, 2004).
Other authors maintain, that while the Likert scale item is technically ordered, using it in parametric tests is valid in some situations. For example, Lubke and Muthén (2005) found that it is possible to find true parameter values in factor analysis with the Likert scale data, if assumptions about skewness, number of categories, etc. are met (Campbell & Swinscow, 2011).

Immediately after the focus group session, the evaluation is started in order to assure an efficient analysis. In general, the evaluation of focus group sessions is not easy. The main reason is, that the interaction of the group generates a social atmosphere and therefore the contributions always have to be interpreted relative to their context (Howe, 1988). Thus, the contents of the group discussion (vs. other possible aspects, e.g. argumentation structures or group dynamic processes) are the focus of attention. A structuring, summarizing analysis of the discussion contents is necessary. Therefore, to keep all the details, it is important to aggregate the key answers for the central question in addition to combining other discussion points, which do not match to this question. This is extremely necessary in order to assure a broad understanding of the topic (Greenbaum, 1998).
While reducing all discussion data in a concept map, the results are summarized in brief so that the main issues can be identified. This map brings together the question topic and the main themes that emerged in the discussion about the concept. The focus group analysis includes detailed information about the participants. For a deeper understanding, it is important to know e.g. the academic / professional level, etc. On the part of the evaluation, the task is to summarize this complex structure of attitudes and opinions without significant loss of information. In accordance with the objectives of focus groups, individual contributions to the discussion are of less interest than the range of opinions of the entire group. The aim of the evaluation is to work out core statements and their relations from the variety of individual contributions, so that the essential results of the discussion are immediately comprehensible.

Via using this concept map, it is also possible to show how these results could be aligned and feature in major conclusions about sustainable business models and the future-charging hub. In particular, the deeper understanding via the discussions will be highlighted in order to finalize an optimal storyline, moving towards the answers for the main research question (Greenbaum, 1998).

By means of triangulation, the qualitative and quantitative analysis results of this research project are to be combined. Hence, triangulation presents method pluralism and thus means the use of different research methods in order to merge their manifold advantages and disadvantages (Metz, 2000, p. 60-74). McGrath argues that every research method, despite its specific advantages, also has inherent, unavoidable flaws and calls this the dilemma of empirical research (McGrath & Kelly, 1986).

Accordingly, the combination of several carefully selected research methods seems appropriate to compensate for weaknesses of one research method with the strengths of another research method and to be able to conclude causalities with greater certainty (McGrath & Kelly, 1986). Therefore, researchers influenced by positivist or post-positivist philosophies have viewed triangulation primarily as a means of overcoming the limitations inherent in using only one approach to research.
Within the discussions about the combination of different research approaches, there are certainly some controversies. While some even see mixed methods as a "special case" of triangulation, others see triangulation as an approach of linking research perspectives, whereas mixed methods are a more pragmatic mixing of operative research methods (Metz, 2000, p. 60-74). Besides, it is also often critically noted that mixed methods is predominantly dominated by quantitative research logic and thus qualitative research with its potential for theory building is not sufficiently taken into account (Metz, 2000, p. 60-74). Notwithstanding these arguments, the challenge of combining several methods is that a broad knowledge of the different approaches is required (Flick, 2014). Finally, triangulation should be viewed in this research project as a tool to enrich the process of inquiry and to allow multiple perspectives and results to emerge. If naturally, discrepancies are captured and different information emerges, the researchers are then challenged to make sense of these differences.

Flick (2014) especially shapes the general definition of triangulation. Within his defined framework, he describes the objectives and various concepts of triangulation such as data triangulation, investigator triangulation, theory triangulation and method triangulation (Flick, 2014). Denzin and Lincoln, 2011 developed an initial understanding of the so-called triangulation and regarded this primarily as a central strategy of result validation (Denzin & Lincoln, 2011). Thus, by combining different methods of empirical research, the same phenomenon is analysed in each case. The application of different methods and theories should, therefore, lead to the greatest possible gain in knowledge and overall verification (Denzin & Lincoln, 2011). The critics' recommendations to Denzin were to consider triangulation as an alternative and as an additional justification for validity, not in the sense of a mutual validation of individual results (Flick, 2016). Different approaches, methods, data types and results should rather converge and complement each other, but not by being accordant (Flick, 2014). They can relate to each other in a complementary way and expand the possibilities of knowledge. Summing up Flick's remarks, primarily, the method of triangulation should be applied if it promises a greater gain in knowledge than a singular approach (Morgan, 1998; Flick, 2014). In this context, the Flick is speaking up for a systematic perspective triangulation, which makes it possible to complement the strengths of the respective research perspectives (Flick, 2014).
Flick emphasizes that this is not about a pragmatically conceived combination of different methods, but about taking into account their respective theoretical background and assumptions (Flick, 2014).
For example, the main pillars of this overall research topic are analysed with the interview approach and in combination with it, the practical sense check regarding new mobility trends influencing business modelling can be recorded with the focus group. This is the systematic approach: with two perspectives on a phenomenon and two different methodological approaches, two types of data are obtained and can be related to each other.

Triangulation thus reveals different constructions and levels of a phenomenon both - here at the level of a broader professional background (interviews and various industries in this research project) and also in the context of a discussion with deeply involved experts (drawing from the focus group session).
On the other hand, a triangulation between methods, offers the possibility that the biases inherent in one approach will be mitigated by the inclusion of other sources of data, methods, and investigators.
As far as Flick (2014) is concerned, the triangulation of independent methods and related results has received the most attention so far and is, therefore, to be applied in this research project. Thus, most notably, this linking of methods must always take into account the respective theoretical-methodological background from which the methods originate. Furthermore, these methods are used in a reflected way in this research project, consequently bearing in mind profound knowledge of the methods. Flick also deals intensively with the possibilities of combining qualitative and quantitative research (Flick, 2014). The extent to which both methodical approaches are equally weighted and to which extent both are related to each other has to be defined individually according to research projects` specifics. In the context of this primary data collection all research methods and results obtained are weighted equally, as each of them has an important function in line with the primary data collection process.
Creswell (2007) explains that when a need exists to first explore qualitatively, a researcher might use an exploratory, sequential design. In this research project, with an exploratory, sequential triangulation, the results of one method inform the planning of the next method. From there the interviews and the questionnaire are used to provide context for the focus group session. For this process of analysis, such a design is very useful, as the main variables are unknown and there is no guiding framework or theory. Since the intent of the exploratory design is that the qualitative results help develop the quantitative method. First, the phenomenon is explored qualitatively and from its analysis, the researcher forms the quantitative research approach – the questionnaire.
In general, there is no empirical and very little theoretical research on the prerequisites for innovative charging business models based on new mobility trends. The lack of empirical studies and the related results to be used in practice are also highlighted in the very few publications on this subject. The central aim of the study is therefore to enable new insights into the object of research and to validate assumptions that have so far only been formulated theoretically. This unique character of the overall trend electric mobility and charging strongly influenced the decision to follow a mixed methods approach with multiple perspectives.

4.3 Study feasibility: data reliability and data validity

Research reliability refers to whether or not the same answers can be attained by using an instrument to measure something more than once. Thus, data reliability is the degree to which the research method leads to stable and consistent results (Pelissier, 2008).
Research validity refers to the extent to which the research instruments, e.g. the interview questionnaire used, the conducted survey or the focus group session, really measure the right elements, which need to be measured. In addition, Robson (2002) defines validity of a research instrument in a similar direction. According to him, research validity assesses the extent to which the instrument measures what it is designed to measure. Referring to Pelissier (Pelissier, 2008) there is a difference between internal and external validity. Internal validity refers to an excellent matching of research findings and reality. In addition, to be mentioned for the sake of completeness, having an external validity means achieving replicability and assuring the possible transfer of research findings to other research environments. The term “validity” is increasingly being used not to refer to the function of the test itself, but how the results are interpreted (Pelissier, 2008, p.12).

In order to assure data validity and reliability for the chosen research instruments, several aspects are considered. As mentioned before, due to the very new research area, the intention is to collect very rich data und to highlight, in parallel the related validity and reliability of the chosen research instruments. Consequently, it is considered that the quality of measuring and of the collected database is of high importance during the entire research project. By using mixed research methods for the primary data collection process, the validity and reliability of research should be increased.
This means having various measures and steps of the primary data collection process; always dealing with the same overall population and, in parallel, various sampling techniques. It is ensured that there are enough participants and that they are representative of the population. This data collection is combined with various qualitative and quantitative analysis techniques, therefore, the validity and reliability are strengthened. At the same time, the integrated step of handing back some findings to the respondents for final explanation has a very positive impact on validity and reliability.
Furthermore, the issues of validity and reliability are addressed through triangulation. Triangulation in general supports the strength of interpretations and conclusions in qualitative research. However, it is also anchored quantitative social research. Bryman and Bell (2007, p. 283) defines triangulation as “the use of more than one method or source of data in the study of a social phenomenon so that findings may be cross-checked”.
In an ideal world, an assessment should be both highly reliable and highly valid. Admittedly, this is difficult to achieve due to the tension that exists between the two. Reliability and validity are closely related, but they have different meanings. The relationship between validity and reliability is that of trade-off: the stronger the bases for validity, the weaker the bases for reliability (and vice versa). A measurement can be reliable without being valid. However, if a measurement is valid, it is usually also reliable. This must also be implemented within the framework of this research project. See the following overview, showing major aspects increasing reliability and validity and also assuring a kind of trade-off (Robson, 2002). See figure 25 for further explanations.

Figure 25 | Reliability, validity and trade-offs (own illustration)

Ensuring reliability and validity | major aspects, via:

	Data Reliability **+++** ***„Consistency of a measure“***	**Data Validity** **+++** ***„Accuracy of a measure“***
Interviews	• **Using semi structured questions and only integrating experts in charging and business, modelling (internal consistency) – test-retest-reliability,** assuring that here should be a strong correlation between the two sets of results (Bryman & Bell, 2007)	• **Extensive training in all aspects of the scientific interviewing process,** assuring adherence to the measure to existing theory and knowledge of the concept being measured **(constructed validity)** (Bryman & Bell, 2007) • **Semi-structured interview approach** - providing some direction for the interviewee, the questionnaire is based on established theory or findings of previous studies, and the questions should be carefully and precisely worded **(constructed validity)** (Bryman & Bell, 2007)
Online Survey	• **Interviews are a major basis of the survey questionnaire design, assuring internal consistency**	• **According to scientific literature, factor analysis has become such a widely used technique for an estimation of “construct validity”** (Bryman & Bell, 2007). The key concept of factor analysis is that multiple observed variables have similar patterns of responses, because they are all associated with a not directly measured variable.
Focus Group	• **Minimizing the influence of external factors** during the process, e.g. aspects and statements, which influence the participants` concentration or mood **– test-retest-reliability**. • **What participants say can be confirmed, reinforced or contradicted within the group discussion. The given high face-validity is especially a corner stone of the related reliability.**	• **In consideration of validity related to the focus group, the research data obtained are the comments and interactions given by participants. This results in a high “construct validity”** to the extent that the informants are free from artificial influences from the environment or the moderator (Robson, 2002). • **The focus group observation protocol is designed to capture all experts` reactions and attitudes** (Schratz & Walker, 1995)

4.4 Approach to research sensitiveness, ethical considerations and mitigation

Research ethics is a world-wide set of principles governing the way any research involving interaction between the researcher and other humans or data relating to humans, is designed, managed and conducted. In relation to this, the following points are to be kept in mind, handled with sensitiveness and also mitigated for this research project (Schratz & Walker, 1995).

For the interviews, ethical issues have to be considered, and it is important to note that, in general, because this is a rather “new topic” there is a lack of experts in the area of electric mobility, charging infrastructure and business modelling. The intention, therefore, is, to integrate participants from other areas e.g. automotive; as there is much more experience with business models in this field.
Due to this lack of experts, it is also a challenge to involve people with the consent of knowledge and required aptitude. A mitigation is only possible via making enough information available in advance about the research to participants, which means taking informed decisions as to whether to take part or not. This a implies, a decision on the interviewee`s participation; to take part due to available expert knowledge or refuse participation because of missing know-how. During this research, participants should, therefore, retain the right to withdraw or remove content.
A major ethical aspect is to find a way how to deal with these issues as an employee of the related company and how to handle colleague-relationships with interview partners. Finally, the fact is that the interviewer is an “insider” within the company who carries out interviews even with direct colleagues. Here colleagues should retain the right to withdraw or remove consent.
The many roles that one individual may have could lead to a conflict of interest, a perceived conflict of interest or an actual conflict of interest (Schratz & Walker, 1995). Potential or actual risk must be mitigated completely and immediately. Two common conflicts of interest include firstly compromising, through coercion, the wellbeing of research participants, and secondly, the impact on research integrity. All conflicts of interest should be able to be identified and mitigated or managed in advance through changes in the research design, especially recruiting participants, and the providing of information. These measures are designed to restrict the impact of human bias or decision-making heuristics on the outcome of the interview-session.

Survey ethics integrates a set of ethical aspects to be incorporated in the research process. These procedures provide strict guidance on how to avoid for instance, that a respondent feels pressured or made to feel obligated to participate in the survey. Accordingly, the intended survey questionnaire contains a reference to the voluntary participation and the right to recall a given input.
In relation to online research, Varnhagen et al. (2005) stress the necessity of informed consent. Therefore, sufficient pre-information has to be provided to ensure that participants are competent enough to do the online survey. In addition, there are considerations about the online type and -layout of the survey. The online format is challenging in regards to traditional research ethics principles such as consent, risk, privacy, anonymity, confidentiality and autonomy (Sugiura et al., 2017). In parallel the online- approach adds new methodological complexities surrounding data storage; security, sampling, and survey design (Sugiura et al., 2017).

The suggestion of the authors Sugiura et.al, is that new ethical guidelines, particularly in relation to informed consent and participants' own perceptions of what is public or private, are needed owing to the unique challenges of online research (Sugiura et al., 2017). In addition to sharing gained information with the informants after the survey or getting them to participate via bringing out that their attendance is of high importance and it has also approved in terms of ethics. This proceeding is not unethical and only demonstrates the appreciation of experts` knowledge and input. However, in order to avoid unethical behaviour, requests for incentives in advance will clearly be refused.

Due to the decision to employ a snowballing sampling technique, details and insights about the population are extremely useful. The relatively new topic and current electric mobility developments strengthen the need for details and information about professional background. However, out of the necessity to adhere to research sensitiveness constraints, questions about, e.g. income and age, will be avoided. This information is likely to be considered as private by the participants. Avoiding such survey questions will assure confidentiality and privacy. The anonymity of the collected data is crucially important for this research project. This is because business modelling or progress in the highly promising field of electric mobility is often considered a unique-selling-point and a business secret. For instance, Sue and Ritter (2012) clearly state that an online survey is not suitable for all research projects. However, Sue and Ritter also identified many areas where an online survey could be a very useful research instrument. In this way, current developments in electric mobility, are likely to lead to a larger and especially geographically diverse sample. Regarding electric mobility and the survey target group, it is also likely that the required internet access does not negatively influence the population. This prerequisite is given on the part of the target group and, therefore, represents the general population.

In terms of the focus group it is highly important to respect sensitiveness and to prevent bias. Integrating bias in a focus group session would be unethical. In this sense, bias means hiding certain findings or disproportionately showing research findings. Therefore, to prevent this, documentation and recording of the focus group session in an unbiased and correct way is foreseen.

Another important restriction for this focus group discussion is the involvement of participants from universities, funded by the employer of the researcher. Their valuable input in this field of study is highly important; however, due to the close relationship with regards to common research projects, especially in terms of this topic, the research ethics are summarized before starting the focus group session.

This summary also integrates the clear prohibition, that obtaining and disseminating accurate information is a high priority. To influence any research findings solely for personal reasons is clearly prohibited.

4.5 Final reflections on the development and structure of research instruments and provisional findings

The main intention of this primary data collection is the fact that it is extremely important to test the knowledge gained via the related literature studies in practice. Often the simple transfer of academic knowledge is not sufficient and will not automatically lead to optimal answers.

While investigating the research topic and looking for a comprehensive answer, interviews and the focus group session have provided very rich information. This is especially so because it is an emerging topic of electric mobility the focus group and interview session could be used to resolve seemingly conflicting information. In particular, during the focus group approach, the researcher takes advantage of the opportunity to ask about apparent conflicts, for instance, about the divergent views on the role of public charging stations as explicit enabler for an electric mobility roll-out in Germany.
The advantage of the research instruments employed in semi-structured interviews and the focus-group session, is the possibility to challenge the informants with regards to the relative emphasis on several aspects. Therefore, the focus group and the interview session were very helpful in determining how strongly the participants hold the opinion that there will be a radical change in mobility behaviours in the near future. By direct validating questions, an excellent picture arose about the change towards a future charging station – the mobility hub. During the focus group session, the researcher always bears in mind group dynamics, meaning situations during fruitful discussions where group dynamics may imply an emphasis that is misleading. For instance, the very strong reasoning of one participant about his general attitude towards technical progress in electric mobility drives has to be guided, in order to assure a continuing yielding discussion. In this way, some disagreements in the data set could be resolved.

Notably due to these group dynamics, very interesting research aspects came up which otherwise would not have been possible. Very important points were mentioned about emerging business model ideas. For instance, innovative ideas about sharing mobility were discussed in relation to the needs of future generations with a completely changed mind set. In parallel, there is the possibility of generalization after the well sampled and structured survey is completed. By contrast, focus group data are never generalizable beyond the group studied. The experts taking part really appreciated a face-to-face discussion, getting some interchange also with other experts, instead of receiving another online or pen-and-paper survey. Then again, other experts indicate that during sessions with other participants, they will not talk about business modelling as being an important part of their corporate strategy and, therefore, to be kept as a business secret. In terms of the anonymized survey questionnaire, this could be handled completely differently. This is especially regarding sharing the research results after the survey has been conducted; the experts are contributing with some confidential and anonymized information.

The mixed methods approach in the context of this research project foresees applying the multi methods in sequence. This was an appropriate decision in order to enrich the database step-by-step through valuable information and being able to use the benefits of qualitative and quantitative methods. Thus, using certain methods in sequence, for instance, qualitative analysis provided by focus groups adds to the interpretation of results found by analysing previously collected survey data. The interviews were even employed as a part of a questionnaire-design process. Using multiple methods can, therefore, enhance the overall research project. To summarize each research instrument and related data collection, a different aspect of the research was addressed. In addition, each research method provided a different aspect of the final research findings. The interview session endeavoured to confirm the main pillars of this research project; meaning the clear need for a public charging infrastructure, always keeping in mind current technical developments. Thus, the interviews provided the researchers with knowledge from the level of the field experts.

The basic questions asked in these interviews were very similar to a cut-out of the questions posed in the focus group, meaning they gave initial guidance concerning the main pillars of this wide research area. The surveys also begin with broader questions about issues affecting readiness, technical developments, and general business model needs. Accordingly, the survey was targeted to quantify the number and proportion of experts in the developing opened field of new and innovative business models and their valuable input to the central research questions – why sustainability is needed and how this sustainability can be assured with regards to innovative business models. The surveys also placed the discussion about public charging into the broader context of electric mobility and technical developments. Specifically, the surveys included open-ended questions asking respondents to list the factors that affect the readiness of public charging and sustainability. The major outcome here is expected to be that only via additional services and a clear trend towards a mobility hub, sustainable business cases can be enabled in the medium term. The focus group conducted for this research effort provided very detailed explanations of charging issues in public structures and also rich practical examples of both the sustainable business case and the development towards “the new mobility hub”. To summarize, the focus groups guaranteed insights and examples and the surveys permitted the researchers to place these fruitful discussions in a broader context.

Therefore, this research project succeeded because of the complementary mix of data collection methods. The data analysis provided the necessary qualitative and quantitative results. Using mixed methods enhances the research possibilities in general and this approach was taken in order to explore, in parallel, the WHY-questions (Why is sustainability required?) and the HOW-question, meaning (“How can the necessary sustainability be achieved?”). These two questions and the multi-dimensioned topic can be responded in an optimal way through mixing the research methods used. Referring to Creswell (2007), a very complex research topic calls for a multiple-methods approach, not only within one paradigm – qualitative or quantitative – but also across paradigms. Using a multi-methods approach also enables such flexibility and freedom in order to obtain the most complete scientific results in terms of charging infrastructure and innovative business models.

Triangulation is applied by using several research methods of data collection, to explore the same issue and in order to contribute to an enhanced understanding of the research phenomenon. Studying the topic from diverse standpoints led to an overall understanding.

Methodical triangulation is also described by mixing strategies or methods to corroborate one against the other (McFee, 1992; Scott & Vargas 2007, p. 11-13). This is a generic definition, but also not the only form of a triangulation strategy. The four basic types of triangulation are: triangulation of data, investigator, theory and methodological triangulation (Campell & Fiske, 1959; Webb et al., 1966)

The triangulation of the research methods in terms of creative business models enriches the data set and enhances the overall accuracy of this research project, as well as collecting additional research evidence. Considering the whole research process, the very new topic was addressed in an optimal way and, finally, the workload, due to a very rich and comprehensive data set, could be managed very well and led to powerful research results. By using more than one method, there is an increase in validity, reliability and generalizability (Karim, 2013).

The results of the applied triangulation and notable findings are illustrated in chapter 5.

CHAPTER 5 | ANALYSING COLLECTED DATA, DISCUSSION OF FINDINGS AND CONTRIBUTION TO THEORY AND PRACTICE

All applied research methods have been thoroughly explained in chapter 4, both in theory and in practical application to this research topic. Directly integrated are also experiences and key learnings from the pilot study. Chapter 5 deals with the results derived for each step of the primary data collection and related analysis. By discussing the most important findings, the intention is to address the aim of the research project. The results will be presented in the same order as the research was conducted. This section also concentrates on investigating connections between the findings and their practical application.

5.1 Data screening process and discussion and summary of notable findings

5.1.1 The interview session – resulting in narrowing down the topic

The interview session was very useful as an initial approach to the topic. The intention was to use the primary data from the interviews to narrow down the overall topic and elaborate the main pillars at the very beginning of the research project. This is, in particular, reflected via the inductive proceeding, within the context of the chosen thematic content analysis. Here, an inductive approach involves allowing the data to determine the exact theme and to develop an initial framework based on the interview findings (inductive). Thorne (2000) characterized data analysis in general as the most complex phase of qualitative research. Accordingly, it was of high importance to ensure the trustworthiness of this research process and to show how the data are analysed or outline which assumptions informed the generic analysis. Qualitative researchers can demonstrate in general how data analysis has been conducted through recording, systematizing and disclosing the methods of analysis with enough detail to enable the reader to determine whether the process is showing credibility (Attride-Stirling, 2001; Ryan & Bernard, 2003). The thematic content analysis is a common analysis method, which provides organised and detailed descriptions regarding the database. In order to evaluate the explicit content of the data in a credible manner, the six step-model developed by Braun and Clarke (2006), was followed in this research project (Coughlan et al., 2007). This model can be considered as very structured approach, with sequential phases, were each builds on the previous. The analysis is typically a recursive process, with intensive exchange between the different phases. Facilitating a rigorous process of data interrogation and engagement is the clear target. In its practical application, the following phases are passed through in scope of the analytic process: familiarisation with the data, coding, generating initial themes, reviewing themes, defining and naming themes, writing up (Braun & Clarke, 2006).
The focus was on a systematic recording of the themes and issues addressed in the interview sessions and link the upcoming themes together under a creditable category system. The final overview should be an initial thematic framework showing all major issues that emerged in the semi-structured interviews. Coding was used to develop themes in the raw data; not just counting phrases or words in a text.

The main reason for choosing thematic content analysis was the related concept of the supporting declaration with data from the grounded theory.
Consequently, it included the construction of theories, which were grounded in the data themselves. This was especially reflective in this analysis, as this process consists of identifying possible themes, reading transcripts, comparing and contrasting themes, etc. In parallel, it gave importance to the participant's different perceptions, experiences and feelings as the major object of study. This was also of high importance, considering that the overall research philosophy used was post-positivism.
For the interviews, five experts have been recruited. Besides interviews with experts from the automotive industry, an interview was conducted with a decision-maker from the energy industry who was already engaged in the ramp-up of charging infrastructure and in discussions with providers of charging infrastructure and their ecosystems. The semi-structured interviews each lasted from 60 - 90 min. The following impressions of current topics and trends in the area of charging infrastructure are summarised from the perspective of these decision-makers. While going through the transcripts of the interviews with the five experts, various codes emerged (figure 26).
In the coding process, it is essential to approach the text in an analytical way instead of merely viewing it with a descriptive focus. Absolutely required for this process is an intensive reading to ensure the identification of all relevant ideas in the text. Charmaz recommends this intensive reading and using here the following key questions:

- "What is going on?
- What are people doing? What is the person saying?
- Which reasons do these actions and statements take for granted?
- How do structure and context serve to support, maintain, impede or change these actions and statements?" (Charmaz, 2006, p. 5-94)

In relation to the first coding process, many phrases and a complete sentence were finally marked. These different codes provided an overview of the most important points and common meanings that recur throughout the interview data. The summary of results is shown in chart no. 38. After arranging the coding and putting the codes into an order, several patterns arose and the complete data set shows consistency as well as four defined themes, which accurately represent the overall data of the five interviews. Frequent statements are additionally marked in blue in scope of figure 26.

Figure 26 | Coding qualitative interview data and generating themes (own illustration)

Themes

1. Key buying factors

➔ The key factors, influencing consumers' willingness to drive / purchase electric vehicles in Germany

Coding		
	Educational level of the consumers	Availability of public charging infrastructure
	Occupation of the users	Financial benefits and incentives
	Annual income of the users	Governmental policies
	The consumer - being an innovator | emphasizing a sustainable & forward-looking lifestyle	Car prices & purchasing costs, leasing costs
	Environmental awareness of the users	Fuel costs
	Cars` performance attributes (E. g. battery capacity, driving range, charging time, efficiency)	Maintenance and service costs
	Market readiness and availability of related car models	Marketing effectiveness

2. Key enablers for a successful public charging infrastructure

➔ Certain criteria to be fulfilled, for assuring a successful public charging infrastructure

Coding		
	Overcoming range anxiety and -envy of users - psychological effect	Significant capacity utilization
	Achieving user convenience	Overcoming the chicken-egg-problem with a wide variety of ideas
	Overcoming users 'uncertainty (E. g. regarding future technical developments)	Providing a social infrastructure
	Price transparency of e-mobility electricity	Sustainable business models
	Harmonized charging standards worldwide	Contribution of the vehicles to an intelligent management of the power grid (E. g. balancing fluctuating wind-and solar energy - energy transition phase)
	Common billing systems	Efficient marketing and communication towards potential users

3. Dominating charging scenario

➔ Future public-centred charging scenario with clear reasons & priorities

Coding		
	Development of technical performance attributes (E. g. battery capacity, driving range, charging time)	Availability of technical charging possibilities at home (e. g. hydrogen and careful handling, normally not being possible at home)
	Evolving driving behaviours	Intermittent renewables, a possible future switch to more daytime public- and workplace charging
	Added convenience of fast charging, enabling long-distance trips	Clear market trend towards electric mobility and mainstream customers → need for a commercially sustainable public charging infrastructure
	Low charging rates at home	Engagement of utility companies

4. Business models for public charging solution – related typology, drivers & success factors

➔ Suitable innovative business models for a successful rollout clearly required

Coding		
	New mobility services - self-determined mobility management	Increased offer of car sharing possibilities
	Multi-modal transport Meeting individual needs	New firms to operate different business models simultaneously
	Overcome “chicken-egg-problem”	Electric mobility service-provider as the new key role
	Digitization	Importance of other service components for achieving an overall sustainability, e. g. shop business
	High importance of the smartphone & related applications	Required transfer points for new mobility services
	Charging price level has to be similar to the case of charging a combustion engine vehicle	The future charging station – a mobility hub
	For the young generation a car is no longer a status symbol	Young generations are shaping the mobility patterns of tomorrow
	Sharing economy	Urbanization and increasing overall mobility

The first theme to be highlighted is “key buying factors” (figure 26); meaning in particular that public charging infrastructure is one of the key factors, influencing consumers’ willingness to drive and purchase electric vehicles in Germany (Attias, 2018). All five experts are of the opinion that the availability of a public charging infrastructure will clearly boost the sale of electric cars in Germany (interview-citation: “clearly boosting the electric mobility ramp-up”). In summary, it can be assumed that public charging infrastructure has the potential to create purchase incentives for the entire electric mobility system. Due to these benefits, other monetary and non-monetary incentives are supposed to be partially replaced or accompanied (Attias, 2018).

The second theme, which came up is “key enablers for a successful public charging infrastructure” (see figure 26). This especially means that certain criteria are to be fulfilled to ensure a successful public charging infrastructure. With reference to the interviews, science and industry, therefore, have to create the basis for an attractive offer to ensure customer satisfaction and user acceptance.

Enabled by information- and communication technologies, customer-friendly payment models for instance must be guaranteed. According to another charging- and electric mobility expert, users should no longer worry about the right plug.

Since 2016, all new charging points in Germany must be uniformly equipped with at least the Combined Charging System (CCS), barrier-free and accessible without prior contractual commitment, the corresponding directive must be implemented throughout the EU. Connector diversity and incompatible charging points should thus be successively outdated; CCS is now established in Europe, the USA and other major automotive markets.

The integrated automotive experts clearly highlight the need for sustainable business models. This is underlined by this example: A normal charging station with an output of 22 kilowatts, at which a BMW i3 can be charged in about three hours, costs between €7,000 and €10,000. However, even at frequented locations, the investment costs cannot be recouped by selling only the charging electricity (interview-citation: “there is currently no business model visible at all”).

The third category (figure 26), which emerged during the interviews, is the “dominating charging scenario”, confirming that there will also be a clear need for a public-centred charging scenario with distinct reasons and priorities (BMWI, 2018).
Two experts from German utility companies, with extensive experience in building-up public charging infrastructure within the context of first lighthouse-initiatives, made insightful comments on this theme. In particular, they stressed that the importance of a public charging infrastructure in the overall electric mobility system depends on a number of influencing factors. Due to the nature of the system, there are many interdependencies, such as different battery sizes, drive technology (hybrid or fully electric), the different user groups (with or without private parking space) and the charging capacity of public charging infrastructure, etc. Furthermore, charging infrastructure in the semi-public sector is to be considered as a (partial) substitute for public charging infrastructure. Due to this complexity, the question of the required scope of public charging infrastructure cannot be answered at present. However, a public charging infrastructure appears to be of great importance for users, especially due to the individual transport nature of electric mobility.
One expert mentioned for example, that the shorter range of electric vehicles is often cited as a barrier to purchase, as it restricts the flexibility of users. Various user surveys of the experts` employing companies (energy supply companies) also underline the importance of public charging infrastructure for convenience reasons.

The fourth theme is “business models for public charging solutions – related typology (figure 26), drivers and success factors”. This category also represents the clear need for innovative business models. Sustainable business models are required for a successful rollout. The integrated experts are entitling new mobility trends and behaviours as major enablers for the required sustainability and success of business models. In the interviews, it emerged that not only additional service components (e.g. shop business) are key points for a profitable business model. Of equally high importance are new mobility trends and behaviours. Due to the clear development towards shared mobility and multi-modal transport services, a profitable business case could be enabled in the medium term. In particular, this means development towards the future charging station – being a mobility hub and combining the full range of mobility offers in order to reach profitability.
According to the experts, the increasing mileage of passenger cars and commercial vehicles, together offer, with new mobility trends, the best conditions for an extension of the service-station business. The filling station becomes a mobility station. With its convenient location, it can combine a wide range of mobility offers and develop completely new service areas.

Finally it can be concluded, that this first analysis shows that deficits in the charging infrastructure are now becoming apparent, and many people interested in electric mobility consider this as a major barrier since the extremely emotional basic need for "individual mobility" is affected. The interest of consumers in this new technology is constantly increasing and shows the need for sustainable business models for public charging solutions. The newly emerging role of the electric mobility service- and charging provider is becoming immanent. New mobility trends and behaviours are resulting in completely new ideas to enrich a positive business case for public charging infrastructure.
Considering the interview results obtained, the main link to the literature is especially that electric mobility is doubtless the most important component in the future mobility mix and will open up another form of individual mobility (Horx, 2019) (interview-citation: “individual mobility is rapidly changing”). Electric mobility amounts to a complete cultural change. The decisive factor will be the successful implementation of the access principle for mobility services, to design the interfaces and business models. In scope of future e-mobility packages, and creating tangible benefit for the users, the charging station, as future mobility hub, will play a highly prominent role (Horx, 2019).

5.1.2 The online survey – expanding the understanding via a widely spread expert survey

Forty-eight professionals participated in the survey. Only 2 selected contacts did not take part for undisclosed reasons. Due to this, the quality of the explorative factor analysis was also positively influenced by a high response rate (90%). The total number of selected participants was high, especially because of the novelty of the topic and the related low availability of experts. The participants came from the same business and research environments, like the interviewees and the focus group participants. However, of course none of the participants took part twice. The average professional experience is 12 years, with different core areas and diverse experiences in terms of electric mobility, charging infrastructure, business modelling and the merging energy- and mobility system. On account of the chosen sampling strategy and scarcity of experts, it was not possible to cover all professional groups with the same share of contribution. Therefore, the majority of the survey participants is representing electric mobility and charging providers (44%), followed by automotive companies (37%) and utility companies (12%); 7% are linked to further participants, e. g. research or consulting. Nevertheless, the combination of experts, which arose via the chosen sampling strategy, also leads to a common understanding and a distinct focus for the research project with a clear relevance for business and science. Based on the evaluation approach of an “exploratory factor analysis”, the data structure of the online survey results was examined.

By means of this widely spread expert survey, the understanding for the overall topic should be widened and, in parallel, this exploratory factor analysis was used for some dimensional reduction. A researcher must select a desired level of precision from the statistics under consideration. Having non-probability samples is an issue with regard to generalization, meaning the possibility of stating the extent to which the research results are representative of what would be found in a larger population.

Therefore, the chosen explorative factor analysis is no contradiction to the decision for non-random sampling. In general the programme used did not take into consideration where the data originated. This only affects the results' generalization.

Thus, the number of variables acquired and the factors influencing successful business models for public charging infrastructure are analysed in detail. With this analytical method, it is particularly important to reduce the wide range of variables to a smaller number of factors, being more central. Therefore, this approach determines whether it is possible that some of the survey answers are results of just a few underlying factors. Besides this, how well each individual variable fits to the whole range of factors examined. Explorative mathematical investigation also means analysing primary data without the existence of a starting hypothesis or without a content orientation towards specific theories. An explorative methodology was chosen consciously, in order to search for the most effective approaches for sustainable business model innovations mathematically and to the interviews as well as the emerging focus areas. The aim is to create factors that interact with each other as little as possible. In other words, to combine variables that correlate strongly with each other into one factor. A factor is thus, a purely theoretical construct that contains information from several related variables, influencing charging business cases.

In the online questionnaire, only the two extreme scale points are named. The scaling points in between are marked with ascending numbers for orientation; from 0 – 10 (not at all (1) | entirely positive effects (10)). The questions on the online survey are subject to a content structure and result in the following 15 variables (Figure 27). On this basis, the survey analysis starts with an initial preparation of descriptive statistics and required key-performance-indicators (KPIs). The results of the explorative factor analysis are specified in figure 27.

The mentioned overview (Figure 27) shows the listed criteria, the respective variables, which positively affect a public charging business case. All included interviewees from different areas – utilities, automotive, charging- and mobility providers or other branches clearly emphasize the future importance of the following issues: multi-modal mobility and mobility-as-a-service, the new sharing economy, the future mobility hub and changing travel behaviours. Figure 27 shows the median and the standard deviation. With the cluster "multi-modal mobility etc.”, a rather small standard deviation emerges. This indicates that the participants relatively share the same opinion. Other highly ranked variables are load management and the integration into the power grid. In parallel, the importance of additional services features several times for instance, via an expanded shop business or restaurant concepts (Figure 27).

Figure 27 | Descriptive statistics

variables	observations	minimum	maximum	median	standard deviation
1 | multi-modal mobility & mobility as a service	48	5	10	8,833	1,078
2 | new sharing economy	48	8	10	8,750	0,786
3 | mobility hub	48	5	10	8,833	1,078
4 | availability of greener cars	48	0	10	6,271	2,703
5 | changing travel behaviours	48	9	10	9,604	0,494
6 | benchmarking other branches	48	0	10	6,313	3,170
7 | integration in power grid	48	0	10	8,042	2,535
8 | sufficient population	48	0	10	6,458	3,519
9 | load management	48	2	10	8,104	2,652
10 | governmental incentives	48	0	10	5,313	2,947
11 | harmonization of technical charging standards	48	0	10	5,979	2,935
12 | harmonization of payment standards	48	0	10	6,250	3,035
13 | cost decline technical charging solutions	48	0	10	5,688	3,183
14 | integrative business model automotive companies	48	0	10	5,563	2,657
15 | additional service components	48	0	10	7,813	2,472

The correlation matrix | Pearson (Figure 28) of the standardized variables was defined afterwards. It applies altogether as the starting point for the factor analysis. Here, negative values indicate negative correlation and positive values indicate positive correlations. Values close to 0 reflect the absence of correlation. Correlation coefficients vary between -1 and 1. Figure 28 shows a heat map indicating the correlations within a colour spectrum from blue for a positive correlation to red for a negative correlation. Correlation coefficients, the magnitudes of which are between 0.9 and 1.0, indicate variables, which can be considered very highly correlated. Correlation coefficients, the magnitudes of which are between 0.7 and 0.9 indicate variables, which can be considered highly correlated. Correlation coefficients the magnitudes of which are between 0.5 and 0.7 indicate variables, which can be considered moderately correlated (Schnell et al., 2013).

The correlations between “multi-modal mobility and mobility as a service” and the attributes “new sharing economy” and “mobility hub” are positive and strong (close to 1). This show the clear interdependences between these variables and those interviewees give equal estimations to this group of questions. This means that in an increasingly mobile society, future charging stations in a convenient location have an important advantage; they are suitable for private individuals and mobility service providers without additional routes, both of which are attainable very quickly. With changing mobility patterns, demographical and technological changes in new mobility services adapted to customer needs emerge and point to a sustainable business case for charging stations.
Correlations between integration into the power grid and the availability of greener cars are also worth mentioning (0.706). These two items are highly correlated, meaning that with an increasing population or market availability of greener cars, the necessity for a power-grid linkage will also be intensified.
The expansion of electric mobility in Germany offers additional opportunities for the energy turnaround. In the future, electric vehicles could be integrated into the power grid using intelligent concepts.

Together, they would form a consumption-based electricity storage system of significant size that could particularly balance out the fluctuating production of wind and solar energy and, thus, stabilize the power grid. This also includes load management, or balancing, means that cost-intensive, one-off increases will be avoided and higher demand charges in connection with capacity and peak loads are prevented. The other variables with high correlations belong to the group of further enablers for positive charging business cases, e.g. assuring governmental incentives and guaranteeing common charging solutions or standardized payment approaches. Moreover, it is important to consider the need to integrate benchmarking aspects with other branches (correlations values between 0.698 and 0.883). The overall standardized “Alpha of Cronbach” is calculated afterwards. Here, "Cronbach's Alpha" is a measure of scaling homogeneity, which can take on values between 0 and 1. Values above 0.8 are considered "acceptable", but, according to Schnell, Hill and Esser, usually much lower coefficients are still accepted (Schnell et al., 2013). Here it has a value of 0.836, which indicates that there is very likely redundancy in the selected variables.

Figure 28 | Correlation matrix, Pearson

variables	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
variables															
1	1	0,728	1,000	-0,145	0,472	0,016	0,026	0,127	-0,046	0,104	0,227	0,188	0,170	0,041	0,140
2	0,728	1	0,728	0,013	0,671	0,032	0,144	0,073	-0,192	0,255	0,330	0,277	0,283	0,089	-0,036
3	1,000	0,728	1	-0,145	0,472	0,016	0,026	0,127	-0,046	0,104	0,227	0,188	0,170	0,041	0,140
4	-0,145	0,013	-0,145	1	-0,014	0,407	0,706	0,128	0,138	0,355	0,296	0,425	0,544	0,612	0,062
5	0,472	0,671	0,472	-0,014	1	0,026	-0,088	-0,065	-0,244	0,233	0,273	0,167	0,298	-0,216	-0,149
6	0,016	0,032	0,016	0,407	0,026	1	0,356	0,395	-0,212	0,698	0,758	0,883	0,777	0,527	0,252
7	0,026	0,144	0,026	0,706	-0,088	0,356	1	0,477	0,082	0,280	0,215	0,386	0,416	0,448	-0,128
8	0,127	0,073	0,127	0,128	-0,065	0,395	0,477	1	0,065	0,353	0,378	0,280	0,268	0,318	0,101
9	-0,046	-0,192	-0,046	0,138	-0,244	-0,212	0,082	0,065	1	-0,219	-0,306	-0,291	-0,225	0,025	0,149
10	0,104	0,255	0,104	0,355	0,233	0,698	0,280	0,353	-0,219	1	0,780	0,714	0,788	0,613	0,268
11	0,227	0,330	0,227	0,296	0,273	0,758	0,215	0,378	-0,306	0,780	1	0,784	0,769	0,547	0,199
12	0,188	0,277	0,188	0,425	0,167	0,883	0,386	0,280	-0,291	0,714	0,784	1	0,876	0,549	0,151
13	0,170	0,283	0,170	0,544	0,298	0,777	0,416	0,268	-0,225	0,788	0,769	0,876	1	0,539	0,165
14	0,041	0,089	0,041	0,612	-0,216	0,527	0,448	0,318	0,025	0,613	0,547	0,549	0,539	1	0,424
15	0,140	-0,036	0,140	0,062	-0,149	0,252	-0,128	0,101	0,149	0,268	0,199	0,151	0,165	0,424	1

variables | legend

1 | multi-modal mobility & mobility as a service	*6 | benchmarking other branches*	*11 | harmonization of technical charging standards*
2 | new sharing economy	*7 | integration in power grid*	*12 | harmonization of payment standards*
3 | mobility hub	*8 | sufficient population*	*13 | cost decline technical charging solutions*
4 | availability of greener cars	*9 | load management*	*14 | integrative business model automotive companies*
5 | changing travel behaviours	*10 | governmental incentives*	*15 | additional service components*

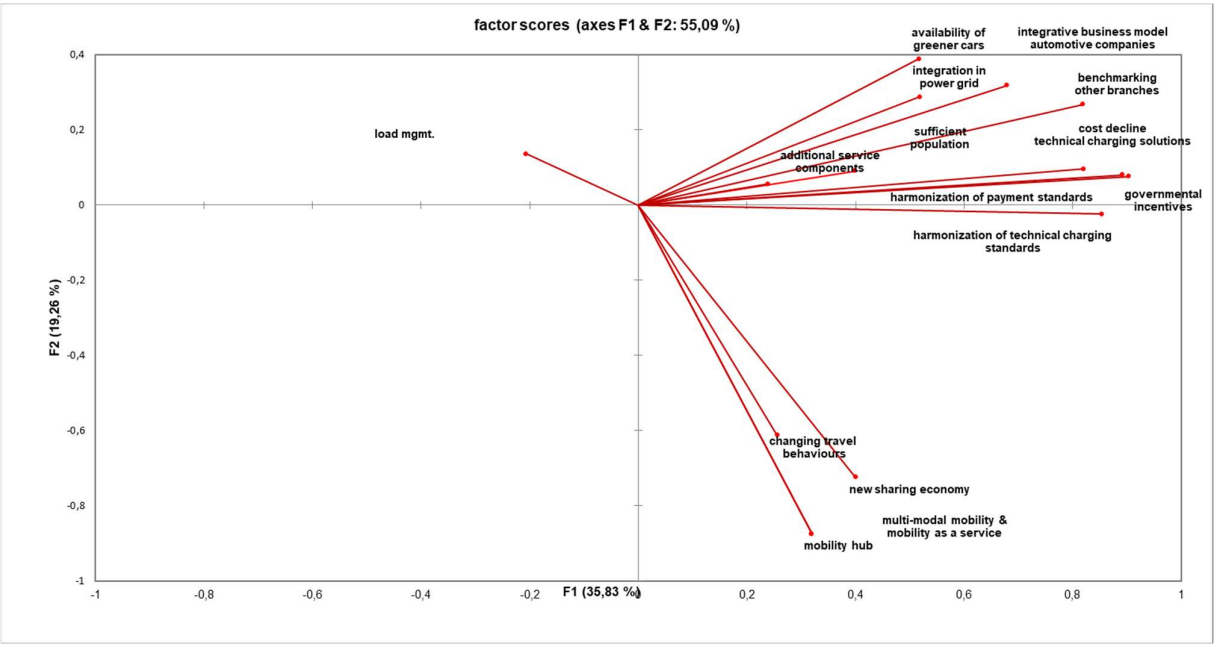
The correlation matrix can be defined by the factor values by reproducing correlations between the factors. The factor scores | factor loadings mentioned below are the main basis for the key interpretation of the exploratory factor analysis (figure 29). The factor values describe the characteristics of the observation objects in relation to the factors determined (Backhaus et al., 2011). In all cases, an interpretation is only possible with profound knowledge of the examined overall topic.

Other possible influences on high factor charges must also be taken into account. According to Bortz et al. (2010), even the way individuals were selected for analysis can influence variables and generate a specific factor influence. The interpretation of the factor scores provides some room for deciding from which score height a variable is assigned to a certain factor. Bühner (2011) considers factor scores > |0.3|. Bortz et al. (2010) and gives alternative guidelines for factor interpretation. According to him, a factor for charges > |0.6| can be interpreted by at least four variables and for ten variables with charges > |0.4|. Backhaus et al. (2011) suggest the consideration of multiple charging items only from charges > |0.5| on each of these factors. However, it should be noted that clear rules do not exist and different values are given depending on the scientist or textbook. According to this, the scores can be clearly assigned, since the items are showing medium and high significant scores on multiple factors. Concerning this research project, the first score-factor is loaded with many items and resembles a general factor, due to this it is called “further enablers” for a sustainable business case | F1. For F2 high negative factor scoring structures are shown and a clustering is possible under the factor headline “mobility hub and new travel behaviours”. Also with a clear mapping F3 and F4 can be comprehensively defined: “power grid integration and load management | F3” and “additional services for charging hubs | F4” (see also figure 30).

Figure 29 | Factor scheme and factor scores | factor loadings F1-F4

variables	F1	F2	F3	F4
1 | multi-modal mobility and mobility as a service	0,319	**-0,875**	-0,234	-0,221
2 | new sharing economy	0,400	**-0,724**	-0,120	0,174
3 | mobility hub	0,319	**-0,875**	-0,234	-0,221
4 | availability of greener cars	**0,517**	0,388	-0,377	0,147
5 | changing travel behaviours	0,256	**-0,613**	0,162	0,369
6 | benchmarking other branches	**0,819**	0,267	0,211	-0,048
7 | integration in power grid	**0,519**	0,287	**-0,737**	0,324
8 | sufficient population	0,400	0,090	-0,200	-0,085
9 | load management	-0,206	0,136	**-0,371**	-0,256
10 | governmental incentives	**0,820**	0,095	0,212	-0,047
11 | harmonization of technical charging standards	**0,854**	-0,025	0,281	-0,021
12 | harmonization of payment standards	**0,892**	0,080	0,182	0,072
13 | cost decline technical charging solutions	**0,903**	0,076	0,132	0,138
14 | integrative business model automotive companies	**0,679**	0,318	-0,202	-0,341
15 | additional service components	0,240	0,056	0,049	**-0,625**

Figure 30 | Factor scores | factor loadings F1-F4



The factors provisionally established by the exploratory factor analysis must also pass a reliability test (figure 31). This research work focuses again on the value of Cronbach's Alpha. Cronbachs Alpha describes the average correlation between the individual items and thus measures the internal consistency of a factor index. According to the input of several statistical practitioners from the Munich University of Applied Sciences, a value < 0.65 is considered critical. In contrast to factor analysis, the polarity of the items also plays a role in reliability analysis, as the first factor shows. The following calculation therefore confirms, the factor definition F1 and F2 – further enablers for a sustainable business case | F1 and mobility hub and new travel behaviours | F2 – with high values of 0,907 (F1) and 0,894 (F2).

Figure 31 | Cronbach's Alpha

Cronbach's Alpha

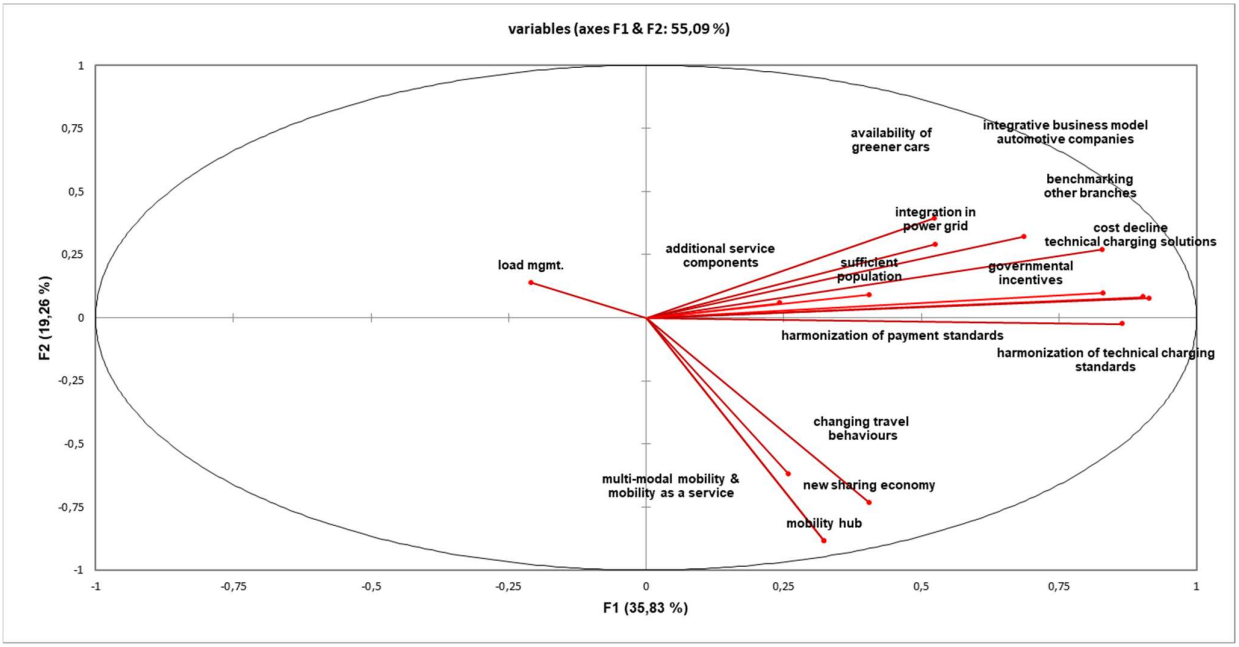
F1	**0,907**
F2	**0,894**
F3	0,151
F4	/

A factor loading of a variable is the correlation between the variable and the factor. For example, variable V3 and factor 2 correlate with -0.885; meaning that the variable V3 loads with -0.885 to factor 2. In theory, values between -1 and +1 are possible. The magnitude of the factor charge indicates how closely a variable is related to a factor: Amounts close to zero indicate that there is little correlation. The higher the value, the closer is the correlation, the connection (figure 32). Against this background figure 32 confirms again the importance and suitability of the F2-definition “mobility hub and new travel behaviours” for this overall research project. All selected variables show high correlations within F2; between -0,620 and -0,885. Related variables are multi-modal mobility and mobility-as-a-service | new sharing economy | mobility hub | changing travel behaviours.

Figure 32 | Correlations between variables and factors (I)

variables	F1	F2	F3	F4
1 | multi-modal mobility & mobility as a service	0,323	**-0,885**	-0,232	-0,245
2 | new sharing economy	0,405	**-0,733**	-0,119	0,193
3 | mobility hub	0,323	**-0,885**	-0,232	-0,245
4 | availability of greener cars	0,524	0,393	-0,373	0,163
5 | changing travel behaviours	0,260	**-0,620**	0,160	0,409
6 | benchmarking other branches	0,829	0,270	0,209	-0,053
7 | integration in power grid	0,525	0,291	-0,730	0,359
8 | sufficient population	0,405	0,091	-0,198	-0,095
9 | load management	-0,209	0,138	-0,367	-0,283
10 | governmental incentives	0,831	0,097	0,209	-0,052
11 | harmonization of technical charging standards	0,865	-0,025	0,279	-0,024
12 | harmonization of payment standards	0,904	0,081	0,181	0,080
13 | cost decline technical charging solutions	0,914	0,077	0,131	0,153
14 | integrative business model automotive companies	0,687	0,322	-0,200	-0,378
15 | additional service components	0,243	0,057	0,048	-0,693

Figure 33 | Correlations between variables and factors (II)



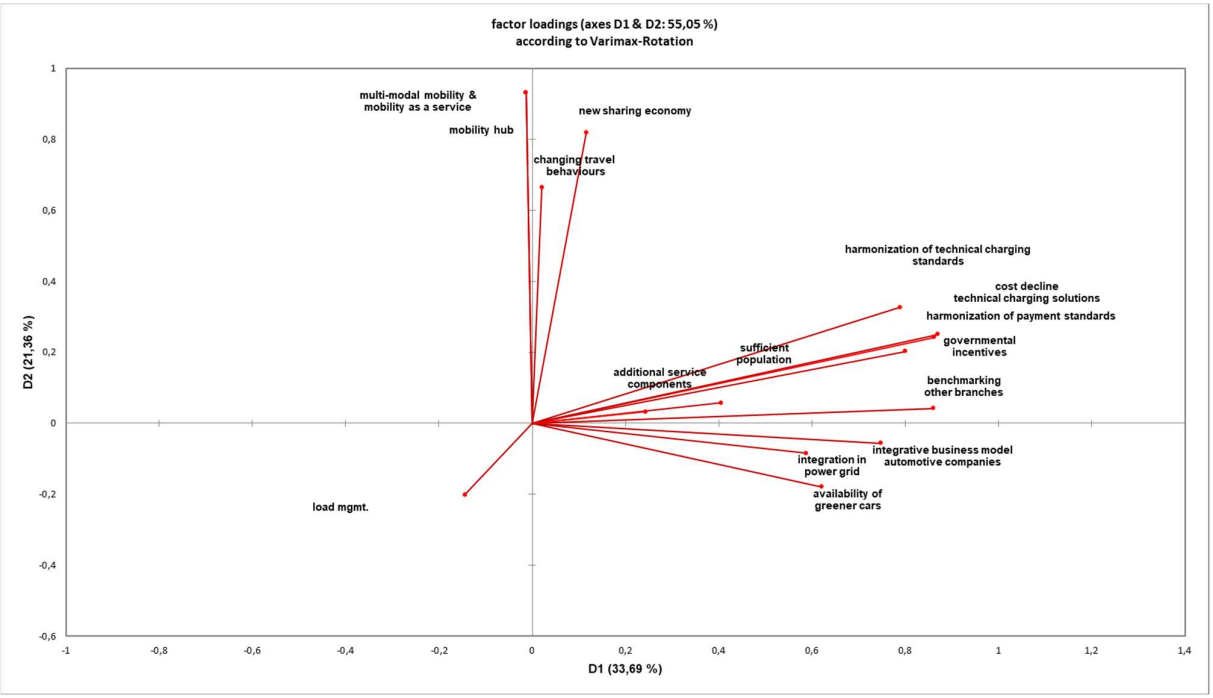
Compared to the un-rotated factor solution mentioned above, the following “eigenvalues of the factors” are more balanced after the Varimax rotation (figure 34). The target is the achievement of factors with a low number of high charges and, in parallel, a high number with lower charges. The intention is to maximize the corresponding charge variance within each factor (Bortz & Schuster, 2010). Therefore, the variance was extracted from earlier to afterwards redistributed factors, the communalities therefore remain unchanged. Factors one and two have the highest share of the explained variance and are therefore confirmed. This also underlines the intention to investigate D2 and the integrated variables further as one single research construct.

Figure 34 | Results Varimax-rotation (I)

Varimax-rotation matrix	**D1**	**D2**
D1	0,907	0,356
D2	0,894	-0,934
Varimax-rotation & variance	***D1***	***D2***
Variability [%]	33,688	21,361
Cumulated [%]	33,688	55,049

Factor scheme & Varimax-rotation	F1	F2
1 | multi-modal mobility & mobility as a service	-0,013	**0,931**
2 | new sharing economy	0,116	**0,819**
3 | mobility hub	-0,013	**0,931**
4 | availability of greener cars	**0,621**	-0,179
5 | changing travel behaviours	0,021	**0,664**
6 | benchmarking other branches	**0,860**	0,042
7 | integration in power grid	**0,587**	-0,084
8 | sufficient population	**0,406**	0,058
9 | load management	-0,144	**-0,201**
10 | governmental incentives	**0,801**	0,203
11 | harmonization of technical charging standards	**0,789**	0,327
12 | harmonization of payment standards	**0,862**	0,243
13 | cost decline technical charging solutions	**0,870**	0,251
14 | integrative business model automotive companies	**0,747**	-0,056
15 | additional service components	**0,244**	0,033

Figure 35 | Results Varimax-rotation (II)



However, exploratory factor analysis reaches its limits as soon as data is available that is not metric or ordinal scaled. The questionnaires therefore provide answers that are categorical but do not have a pure ordinal scale level. Items such as gender, occupation or industry type are generally problematic when working with exploratory factor analysis. Unfortunately, this means that this additional information cannot be automatically linked to the analysis (Backhaus et al., 2011).

Respectively, this additional information has a huge impact on the answers. For instance, branch-specific information mainly influences thinking and incorporating certain items in the questionnaires.
To summarize, this investigation of the interdependencies between variables is important in order to quantitatively address the overall research question. In science, an explanation of many phenomena is often only possible by a multitude of influencing factors. Thus, the recognition of mutually independent descriptive and explanatory factors from a large number of variables is of high importance. Apart from the elimination of multiple values, correlating variables and related factor loadings are the main outcome of the factor analysis, resulting in a realistic model and clear guidance for research focus. In this exploratory factor analysis, the following main factors were successfully defined:

- Further enablers for a sustainable business case | F1
- **Mobility hub and new travel behaviours | F2**
- Power grid integration and load management | F3
- Additional services for charging hubs | F4

The derived factor 2 | F2 clearly confirms that various means of transport will no longer be available in competition with each other; their use will be intelligently and innovatively interlocked. Mono-linear mobility is a concept of the past, but much more important in the future is to decide on the situational best-suited mobility device, according to the individual's needs. The major problem in using a variety of mobility offers is in the transition between the different means of transport. This should be enabled by the future charging point, converted into a mobility hub and covering multi-modal transport services. Finally, the major pillars for this research project, together with the investigated business model sustainability and profitability are confirmed via the results of the factor analysis. Via this explorative approach, the direction of research and the focus of business model research is clearly underlined.

5.1.3 The focus group session – a concluding sense check by practitioners

The major influences on a profitable charging business model are finally discussed within a focus group session. In the context of this focus group debate, a sense check with certain experts is made. The key topic of the focus group is, especially, challenging the attitude of the experts involved in the direction of the real contribution of new mobility trends and behaviours to innovative business models of public charging infrastructure. The integrated field-experts are asked for their estimation about the charging station as a future mobility hub and the related medium-term effects on profitability and sustainability. With a concept map (see following figure 36), the content of this focus group is aggregated to core statements. The concept map, in parallel, structures and presents relationships in order to clarify connections (Nückles et al., 2006).

The 12 participants appointed to the focus group represent different professional backgrounds, research institutions, universities and enterprises. The integrated companies are charging and mobility providers and utilities, as well various enterprises from different industries, e.g. traditional automotive companies, manufacturers of electric cars or a 3D-printing company. Finally, an expert is integrated, also from the consulting business. The average professional experience is 16 years in diverse business areas and fields of study; which also underlines the overall expertise with regards to business modelling.
The major discussion points concerning the real influence of new mobility trends on future public charging business cases has been summarized in the following concept map and respective evaluation. The discussion with a total duration of 3 hours (with a break of 15 min) was started by the moderator with the overall question about future mobility and the newly emerging role of the electric car. The experts agreed that the automotive industry and politics are increasingly setting the directions. Decarbonisation is becoming the fundamental economic principle and the most important driver of the changes in mobility. By making electric vehicles an integral part of the smart grid, they will advance to become a game changer for the business models around the electric car and the energy industry. It is also apparent that politically driven, fuel-cell vehicles and hydrogen charging will be encouraged and enter the worldwide markets gradually (see figure 36).
According to all participants in the focus group session, this is the major starting point for all further considerations. The electric car will increasingly play a complementary role in the future mobility mix. Nevertheless, the car will continue to be a central driver of the electric mobility megatrend, albeit under new circumstances and always considering smart and multifunctional mobility solutions. This means that the electric car is no longer used primarily as an object for status staging. The car has moved down in this staging hierarchy. In accordance with the field experts involved, it is increasingly becoming a digital partner. In this context, reference is also to be made to the literature review and the authors Chase (2015) and Loose (2016), who are also emphasizing this development. Thus, the car is an important building block in a large mobility offer matrix. Here, the experts also state that the mobility mix is clearly shifting towards intelligent means of transport in the form of an individualized public transport, integrating an intensified usage of e-bicycles and e-car sharing (see figure 36).

In addition, the boundaries between public and private mobility are dissolving and related mobility offers are merging. One expert suggests that demographic changes are becoming a driver of innovative mobility; the group between 60 and under 75-year-olds is developing towards being a key driver for new multimodal mobility offers.

As per the focus group discussion, high status is no longer defined by the collection of air miles or membership cards of the most expensive airlines, but rather by the personal competence to choose smart mobility solutions and the right mobility mix. Accordingly, the new sharing mobility trends are promoting inter-modality and the offer of flexible mobility services by various means of transport - car, train, bus, taxi or bicycle; preferably electrical-driven. The megatrend electric mobility is, thus, entering a recursion loop, also due to the possibilities of digitalization and the smart phone. The field-experts confirmed that the newly arising sharing economy and multi-modal transport offers can only be enabled by digital services; hence, the smart phone is in some ways replacing the car as a status symbol. IT-based access to sharing systems is a smart alternative in the overall ecosystem of mobility, especially in urban centres. This is as well shown in the literature review and by the authors Guyader & Piscicelli (2018).

The way we are moving around is changing radically and in the future, individuals will no longer buy mobility products and related possessions. Mobility will function according to the access principle: People buy the temporary access to mobility products. Digital services will, in future, also determine the way in which people are mobile. Digital networking, therefore, becomes the major part of the mobility control system and mobility on demand. The megatrend connectivity is becoming the basis of tomorrow's mobility. Digital Networking not only ensures more mobility offers. It is completely giving rise to new mobility structures, through data exchange between road users, vehicles and their surrounding infrastructure. Thus, digital services are enabling the new sharing economy and on-demand-mobility (see figure 36). Different levels of mobility are being reached which means a self-controlled system of real-time traffic planning with on-demand availability and smooth transitions from one means of transport to the other. Please also see literature review and Sumantran, et al. (2017) or Wildemann, (2018).

Participating employees of a research institute clearly state that society`s definition of mobility is coming into existence and involves the desire for simplicity and environmental friendliness, as well as the need for the guarantee of a smooth arrival. Only through comprehensive, IT-based mobility management, will mobility and charging service providers be able to design and organise innovative services along mobility chains. Therefore, a mobility service provider becomes the invisible companion in the mobile everyday life in a world of being on the move. These are the key new roles needed in the electric mobility ecosystem. All invited experts confirm that these are the new mobility trends, behaviours and the clear need for inter-modality service solutions against the background of electric mobility. Concerning the major question with regards to business case sustainability and profitability, all experts acknowledge that for all new mobility offers, various stops and pick-up locations are no longer suitable. New intermodal transport offerings will be combined at filling stations because there is sufficient space and a traffic-favourable situation. The filling station will be the transfer points for “on-demand-mobility" and the charging business will be successfully enlarged by new mobility offers.

The charging hub will link new service areas together and will achieve the sustainability and profitability of underlying business models. At the same time, the megatrends urbanization and increased overall mobility are leading in the direction of a mobility hotspot, where people park for different leisure activities, e. g. shopping or visiting a restaurant, not only for charging.

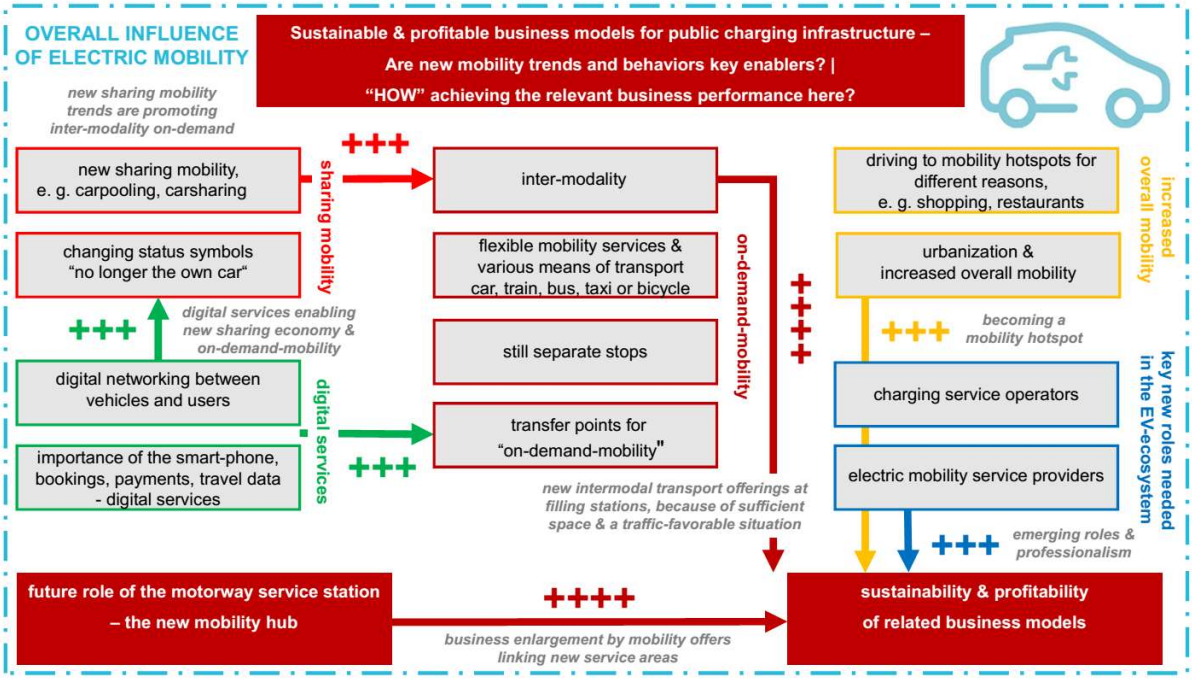
One expert summarized an important example in Switzerland. According to him and this example, it may well be that larger electricity filling stations will have to move in the future. Namely to locations with a direct connection to the medium-voltage grid. What such huge charging centres could look like will be seen in Switzerland from 2023 onwards. A "mobility hub" is to be built there near Basel on the A2 with a completely new mix of offices, services, businesses and 340 charging stations for electric cars on nine floors.

For these reasons, figure 36 summarizes the need for a sustainable charging business case and the feasibility of achieving it via the integration of new mobility trends and behaviours. The focus group results are verifying that successful commercial business model parameters can be shaped by future mobility. The illustration below shows the major developments and trends, like “sharing mobility”, “digital services”, “increased overall mobility”, “on-demand mobility” and the “new roles in scope of the electric mobility eco-system”. This progress is confirmed in the focus group and the frequency of answers is represented by the + sign, clearly showing the importance in the course of the final sense check with practitioners.

Summarized in brief, the experts voices are leading to the following key-results, illustrated in figure 36:

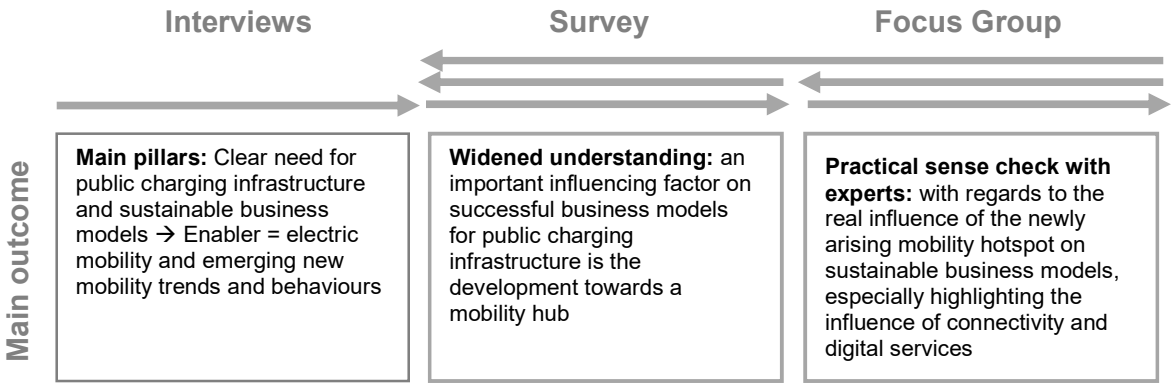
- New sharing mobility trends are promoting inter-modality on demand
- Digital services enabling new sharing economy & on-demand mobility
- Emerging roles and professionalism in the electric mobility eco-system
- The charging hub is becoming a mobility hotspot
- New intermodal transport offerings at filling stations, because of sufficient space and a traffic-favourable situation
- Business enlargement by mobility offers, linking new service areas – at the mobility hubs
- Sustainability and profitability of related business models and electric charging stations

Figure 36 | Concept map focus group session (own analysis and illustration)



5.1.4 Discussion and summary of notable findings

Figure 37 | Summary and triangulation of notable findings (own illustration) (I)



After the completion of the data collection and method specific analysis, the final evaluation summary for this study references all used methods – the interviews, the survey and the focus group session (figure 37). The analysis of the first interviews determined the main pillars of the research project. Accordingly, the interview findings defined the exact theme and developed the first framework premises. Thus, the clear need for a public charging infrastructure in Germany and related business models became immanent and is presented in a thematic content map. Referring to the interviews, there is also a necessity for a public-centred charging scenario with distinct reasons and priorities, in particular due to the individual transport character of electric mobility. The major enabler for the requested business model profitability and sustainability are upcoming new mobility trends and behaviours.

The following online survey is designed on the basis of these first research findings. Hence, the upcoming factors, which influence successful business models for public charging infrastructure, are analysed in detail via this online questionnaire. Afterwards, a statistical analysis of the data collected in the experimental part of the study is performed. A general assessment can be made based on these results, concerning the proven significance of new mobility trends for a business model development.
The final evaluation of the research question and the subsequent interpretation of the results is carried out with reference to all data collection and evaluation procedures. After completion of the data collection, the evaluation of the investigation is always carried out with reference to the previously used method(s). However, a deeper and more realistic classification of the data is only made possible by reference to the results of the qualitative focus group discussion. Only the inclusion of this investigative context then enables a further interpretation and the desired practical applicability.

Concerning the methodological procedure, it is crucial that the data obtained by the focus group can be assigned a justified significance. Some irregularity in questions 6 and 15 were also clarified as a result of the focus group. This has to be verified due to higher standard deviations in the context of the explorative factor analysis for questions 6 | “benchmarking with other branches” and 15 | “additional service components”.

The focus group clearly confirms the significantly higher valuation scores for these questions. In particular, the substantiating discussion in the focus group gives these somehow deviating figures a secure and justified meaning.

The multi-method procedure used filters out many more aspects and findings in the course of the study that might have remained hidden from a single method if applied strictly. On the one hand, the results of the online questionnaire supported the thesis by showing the high significance of new mobility trends for business model innovation and helped to provide further and substantiated findings. On the other hand, irregularities and contradictions also revealed in some areas. Nonetheless, these calculated figures can be justified and substantiated by the results of the final focus group. One major example is the upcoming megatrend connectivity, becoming the basis of tomorrow's mobility. Thus, according to the focus group, the emerging digital services are enabling the new sharing economy and on-demand-mobility. The quality of research can be increased by comparing results on one and the same issue that were obtained in different ways (Mayring, 2002, p. 147).
In retrospect, by linking the data at the collection and evaluation level, it was possible to obtain more complete and more realistic results, which also have a practical value (see figure 37 | by providing and overview triangulation of research findings - primary data collection). In this way, it becomes obvious that in a methodical triangulation, the way in which the different data produced are linked with each other is of central importance and requires constant, even theoretical reflection at every stage of the research project. The significance of individual methods that are assigned to a research paradigm is not diminished in this way. Rather, for certain special research questions, triangulation offers the possibility of an alternative that "increases the breadth, depth and consistency of the methodological approach" (Flick, 2016, p. 520). See overall triangulation summary as follows (figure 38).

Figure 38 | Summary and triangulation of notable findings (own illustration) (II)

1. Part | Interviews

Interviews | resulting in narrowing down the topic and main pillars

5 Experts

Thematic content analysis

- Inductive proceeding - allowing the data to determine the exact theme and developing a first framework based on the interview findings.
- Also underlined with concrete interview examples and linkage back to literature.

Analysis outcome

- Public charging infrastructure is one of the key factors influencing consumers' willingness to drive and purchase electric vehicles in Germany.
- A major enabler for assuring a successful public charging infrastructure - clear need for a sustainable and profitable business model.
- Necessity for a public-centred charging scenario with distinct reasons and priorities - individual transport character of electric mobility.
- Electric mobility is the most important component in the future mobility mix. It will open up another form of individual mobility (Horx, 2019). New mobility trends and behaviours are major enablers for the required sustainability and successful business models. This means that, in particular, the development towards the future charging station – being a mobility hub and combining, the full range of mobility offers in order to reach profitability.

2. Part | Online Survey

Online survey | maximizing the understanding via a widely spread expert survey

The factors, influencing successful business models for public charging infrastructure are analysed in detail via this questionnaire.

48 Participants, 50 addressed, feedback rate 90%

Exploratory factor analysis

- Explorative mathematical investigation, means analysing primary data, without the existence of a starting hypothesis.
- This approach determines whether it is possible that some of the survey answers are results of just a few underlying factors.

Analysis outcome

- The correlations between "multi-modal-mobility and mobility-as-a-service" and the attributes "new sharing economy" and "mobility hub" are positive and strong.
- In an increasingly mobile society, future charging stations with their convenient location have an important advantage, they are suitable for private individuals and mobility service providers without additional routes, being attainable very quickly.
- F2-definition "mobility hub and new travel behaviours" with clear impact on sustainable and profitable business models.

3. Part | Focus Group

Focus Group | The focus group session – a concluding sense check by practitioners

12 Participants

Concept map

- Especially challenges the attitude of the involved experts towards the real contribution of new mobility trends and behaviours to innovative business models of public charging infrastructure.

Analysis outcome

- The charging hub will link new service areas together and will achieve sustainability and profitability of underlying business models.
- The megatrends of urbanization and increased overall electric mobility are leading to the way towards a mobility hotspot.
- The megatrend connectivity is becoming the basis of tomorrow's mobility.
- Thus, digital services are enabling the new sharing economy and on-demand-mobility.

5.2 Derived business model framework for a public charging station – future mobility hub

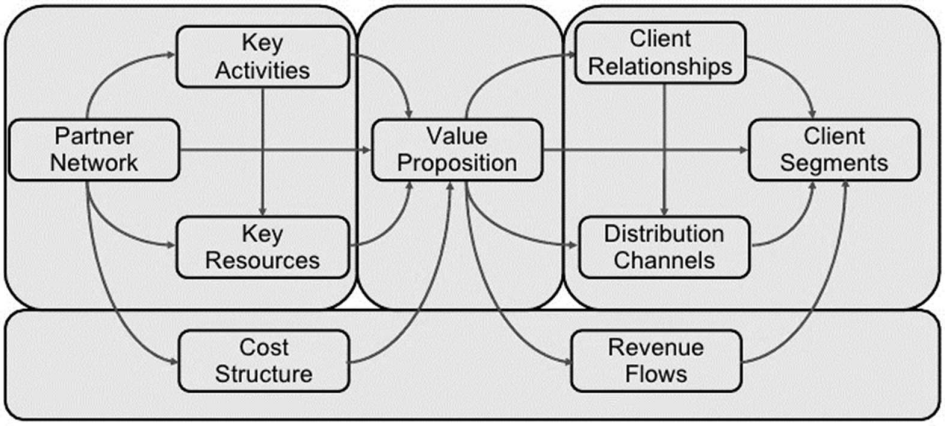
5.2.1 Business model framework

In the literature, there is currently no clear vision how the economic concept of a future charging station would be influenced by changes in mobility patterns. Nevertheless, the emerging expectation is the development towards a hub for smart mobility services. Through growing electric mobility demand and related range-anxiety issues, the need for public charging infrastructure is becoming apparent, especially along highways, at destination points and close to public transport hubs. Simultaneously, mobility culture is developing towards shared and autonomous driving and the improving performance of batteries. Besides, cities continue to restrict city-centre access for personal use vehicles. Thus, the optimal location for the charging infrastructure will change and hubs in the outskirts of cities will consolidate and offer a variety of mobility services. This is, in parallel, the major finding of the primary data analysis; in particular signalling the need for implementing a profitable future-charging infrastructure while anticipating the transformation of mobility. Digitalization simplifies customer requirements and experiences and supports an efficient infrastructure usage.

The major outcome of this thesis is the following business model framework, elaborating profitability via integrating future mobility trends and related new services as additional sources of revenue. It is not the focus of this thesis to provide exact results, but rather to develop a framework with certain premises and estimations for the potential of public charging, based on robust data sources and assumptions.
In this regard, the business model “Canvas” of Osterwalder and Pigneur (2010) is used. The basic theory behind business models and, especially, the approach of Osterwalder and Pigneur are explained in chapter 3. Against this theoretical background, a blueprint approach is drawn to shape the business framework for a future charging- and mobility hub and thus, a clear guideline for the intended business model innovation is defined.

As stressed by Joyce et al. (2016), this is an inside-out approach for a business model innovation-process by exploring the potential changes (Joyce et al. 2016). Numerous companies are intensively using this practical tool to understand, design and introduce new business models; by sharpening their overall value proposition and other strategic tools and processes (Osterwalder & Pigneur, 2010). Here the following sections and, especially, the interdependencies alongside of value creation and -delivery, value proposition and value capture are well visualized (figure 39).

Figure 39 | Business Model Canvas (Chesbrough, 2007; Osterwalder & Pigneur, 2010, p. 56)



The public charging infrastructure plays a key role in the change towards sustainable mobility. In accordance with the changing value chain of individual and collective mobility, the public charging infrastructure can be a link between the user and the value chain of mobility and emerging business areas. Against this background, the aforementioned nine Canvas-building blocks, an innovative charging hub business model is defined. While elaborating a profitable and sustainable business model, the changing mobility trends and behaviours are consequently considered.

1. Customer Segment

The elaboration of customer segments, target groups and specific customer requirements, is the core of every business model, which influences all other elements. Due to this, the first step towards the overall business model framework is the mapping of different customer segments being part of the future solution.

Segmentation can be done in many different ways and, in this regard, Stenzel (2019) states that it is important for service-oriented companies to differentiate their customers in accordance with the level of services they are expecting. The basic assumptions of this business model rely upon a service scenario that envisages strong decarbonisation and the highest level of environmental awareness.

In this scenario, it is assumed that in the medium-term, electric cars and fuel cars will take the market equally (Sonnenschein, 2001). Thus, the key players are the electric mobility customers, also known as e-mobility users. E-mobility users apply charging services to recharge their electric vehicles, inclusive of payment and parking services. In the medium term, it can be assumed that the customer contact resulting from the public charging infrastructure will be used for other electric mobility business models and multi-modal mobility services. Thus, e-mobility users, in accordance with the future charging hub, can be divided in the following consumer groups (figure 40):

Figure 40 | Business Model Canvas – customer segments (own illustration)

Consumer segments | user groups according to expected service level	Requirements – major examples
1. Charging services • Spot loading or e-Roaming and authentication • **For business- and fleet customers** • **For private clients** • In case of vehicle ownership or shared vehicles | shared mobility • Considering the availability of alternative options - home charging or charging at company premises	Charging services, related to the future energy mix
2. E-mobility- and multi-modal mobility services | business- and fleet customers B2B	Car sharing for commercial- and fleet customers, fleet management, billing services, transit point | mobility hub, link to public transport
3. E-mobility- and multi-modal mobility services | private clients	Car sharing, bike sharing, ride sharing, billing services, transit point | mobility hub, link to public transport
4. Vehicle-related services	Battery exchange, repair and maintenance
5. Additional services • Cross-Selling of products and services from other business areas	Restaurant, shopping, leisure activities, bicycle boxes, package boxes

2. Value Proposition

Once the value proposition can be determined, the value that a company generates and delivers can be better perceived by customers. This is a crucial aspect at the very beginning of the business model definition. The value given to customers must be also defined for the respective customer target group, meaning that the value proposition could vary per stakeholder segment. This value proposition describes the bundle of charging and mobility services in terms of the intended widespread value for all customer groups. The focus group results revealed that the most important value for all end customers embodies safety, convenience, accessibility, price, charging performance, well-designed multi-modal mobility services and environmental awareness. Thus, in this Canvas-part the already known values provided today are described and, in particular, the value proposition of the future charging business model is summarized (Müller & Thoring, 2012).

Successful business models for public charging infrastructure must take the future development of mobility into account. The value chain of mobility is changing substantially and the public charging infrastructure is becoming one of the decisive criteria for entering newly arising value chains. On the one hand, mobility will be oriented from product to service. In other words, ownership of the vehicle will be supplemented or substituted by mobility services. On the other hand, there will increasingly be a substitution, or supplementation, of individual vehicles by collective mobility. A breakdown of current developments shows that this will change the overall value chain of electric mobility as part of individual mobility. Public charging infrastructure and links to the energy and mobility sector will play a key role in this value creation process (Wildemann, 2018, Ritter & Schanz, 2019).

The specific advantages, from which customers of the filling station benefit, include not only charging, but also comprehensive services for the vehicle, shopping facilities and, successively, mobility-as-a-service. As in the past, it can generally be said that fuel sales are no longer the primary source of income for the charging stations, but rather attracts customers as a frequency provider, who then receive the lucrative additional offers. In order to be able to use the services offered, customers optionally receive a membership card and can use it for all charging- and mobility services. This strategy can bind consumers to the company in the long term and strengthen the relationship between the filling station / mobility hub and consumers.

Having said this, the exact charging time of electric cars (battery-driven) must be viewed critically, as it is not yet possible to predict this exactly. The experts' opinions on the required time spectrum diverge considerably on this point. After extensive research, a charging time in the range of 10-20 minutes seemed most likely (BMWI, 2019). Based on this assumption, a business model is, therefore, enriched with elements, which reduce the waiting time for the customer as an approach to offering new services through the new filling station.

For the customers, this charging time may represent lost time. Our target segment has a very strong need to use its time as effectively as possible. Effective use of time here means that, on the one hand, the avoidance of charging time in general via using multi-modal transport and not being the owner of a car. On the other hand, for instance, consumers can invest the time in doing some work or physical and mental regeneration. The filling station of the future offers a programme to customers that meet these needs during the loading time. The offers are designed in such a way that all the trends identified are considered.

3. Channels

Communication channels and distribution channels are a prerequisite for customers to learn about and purchase the products. Thus, the “channels” represent the company’s interface with customers and play a key role in the overall customer experience. The major outcome of the focus group session was the clear enabler of such a charging business model, meaning “digital services”. The literature review has also shown the extremely high importance of the smart phone as an instrument for accessing multi-modal mobility. For younger generations the smart phone is of even higher relevance than car-ownership (Wildemann, 2018).

Thus, the main prerequisite for such a mobility hub is to address various actors via a common digital platform. The manifold interactions between different customer-groups and further actors have to be combined through this digital platform, meaning the interactions of charging and mobility customers (private or business customers) with the service providers. The mobility hub relies on this digital platform (mobile App and website) through which the end user gets access to all services necessary for charging, travel planning, booking, ticketing, payment and further real-time information.

Via this approach, different technologies are combined; devices such as mobile computers and smartphones, mobile e-ticketing, e-payment systems and database management systems.

The end users must register on the mobility platform to access the available services. The subscription not only enables the use of the services, but also allows the personalization of the services. This personalization ensures that the requirements and expectations of end users are met more effectively and efficiently by taking each individual customer into account.

4. Customer Relationships

This element describes how the business relationships with the individual customer groups are structured. A company can choose among various approaches. In general, customer relationships boost sales and shape customer experience. Electrical charging and mobility services already have and will have the new business model solution, different relationships with diverse customer segments. The focus group session with field-experts gave a much better understanding of the established relationships and the requested service offerings for the different segments. These were assumed for the future solution in order to provide the intended value. Therefore, the analyses also show that, on the one hand, there is currently a high level of market dynamism in the development of a public charging infrastructure and, on the other hand, that competition for customers and attractive locations is already underway (Abdalrahman & Zhuang, 2017).

Nevertheless, customer-specific adaptation is of high importance. Customization allows the end-user to tailor the service option offered to his needs based on individual preferences. This can increase the attractiveness of mobility services to travellers and their customer satisfaction and loyalty. The primary source of income for the charging station remains “the sale of services”. Here, the future focus is on increased charging services and efficient multi-modal mobility combined with high environmental awareness. The related services should be offered individually, in individually-desired combinations and also as an all-inclusive package, which are paid for by a membership fee, for instance. Existing approaches also stress the potential to combine transport services with services from other sectors, such as entertainment, tourism or restaurants. However, the concept of a new mobility hub focuses on the user, people or goods and on offers mobility solutions tailored to individual needs. This means that easy access to the most suitable means of transport, charging or service is included in a package of “flexible mobility offers for the end-consumer". This personalization of charging and mobility services is the central sales and marketing argument.

5. Revenue Streams

The purpose of all business activities is to achieve profit. Thus, the revenue stream defines how revenues are generated. Profitability calculations are facilitated together with the building block cost structure. The revenue can be generated via various approaches, depending on what pricing method is established. According to the literature, nowadays the most common pricing strategy is purely cost-based. Keeping this in mind, Macdivitt and Wilkinson (2011) presented in detail that this is an insufficient means to realize the potential revenue in companies that offer services.

Ingenbleek et al. (2003) mentions that the value-based pricing approach is far superior to the cost-based and leads to higher margin earnings.
To capture returns from the value created to customers, the revenue and cost need to be addressed in accordance with the product-service bundles and other measures concerning the value creation for customers. This illustrates the way the service provider can apply value-based pricing and how the financial value is generated. It also seeks to determine whether there are other valuable benefits obtained for the charging operator, apart from monetary benefits and how the metrics for business success should be defined. From the customer's point of view, it is important to reveal what benefits the customer is willing to pay for and what value the customer gets. Metrics are equally important in defining how to measure customer success, to ensure that the value offered is being achieved for the customers. The primary data collection in this research project leads to a future solution, with revenues created through value-based pricing and developing other revenue streams, which do not exist today. Revenues will be generated by the sale of the future fuel mix, supplemented with restaurants and shops or advertising and personalized mobility services - generating further revenues (>50% of the income).

Furthermore, it is highly uncertain how the sales figures of electric cars and governmental regulations will develop, but for the medium-term, an optimistic 50:50 split will be assumed – meaning the same amount of electrical and conventional driving. In particular, the pricing strategy is fundamentally different from that of a conventional filling station, as we know it today. As well new legal framework conditions have been applied here.
At traffic hubs or motorways, where users spend short periods, high charging capacities are much more attractive. The related market analysis of the underlying price models of the public charging infrastructure also shows that the possibilities for price positioning is greater for fast charging than for normal charging. In principle, the faster the road on which the charging infrastructure is located, the higher the charging capacity should be. On the basis of the market analysis for charging services, the price- and tariff models can be classified into the following elements: basic fee and usage fee, performance-based fee, transaction-based fee and, if applicable, other elements, whereby not every price and tariff model includes all elements. The clear recommendation of the focus group discussion was to offer users two types of tariffs for access mobility services "mobility package" and "pay-as-you-go". Various options are also being considered within the tariff packages. In the case of cheaper packages, this could exclude the possibility of choosing the route and means of transport. Users would then not be able to decide for themselves how to reach their target destination (Attias, 2018).

Priority must be given to establishing sustainable business models. This is not just a matter of covering costs, but of scaling to achieve critical mass in order to move from niche to mainstream. The usage rate or number of users can be interpreted differently. However, it is currently too low with regard to a sustainable concept. Therefore, a change in the tariff structure can result in a significant boost in demand. The options of tariff incentives should definitely be included in the calculation of related measures.
This can be implemented, for example, by combining tariffs (e.g. flat rate | Mobility SmartCard), offers and user benefits for ride-sharers or charging alongside the prime time. In this context, cooperation with local scientific institutions and/or institutions for business development and innovation management is a very good option (Damm, 2018).

6. Key Resources

This category defines the key resources required to meet the value proposition and to serve customers. The key resources needed always depend on the type of the business model. As financial and human resources are limited, it makes sense to concentrate initially on a small number of actors and a few target groups and tailor-made services for them. Here especially, the focus group discussion provided an understanding of how this category is fulfilled in today's product portfolio and how adjustments are to be made for the future solution, e.g. the high importance of digital products and -services. In order to assure charging hub accessibility, IT-competence and user orientations are essential for a successful business model. The aim is to improve the accessibility and interconnectivity of mobility options. It is based on the provision of all information and services relevant to users (Osterwalder & Pigneur, 2010).

When developing a mobility hub concept, an IT-platform must be set up and operated. To do this, public and private providers must work closely together to develop an intelligent and integrated transport system that is convenient for the user. Furthermore, an open interface is necessary to facilitate the integration of new services and assure an overall service orientation. The related App can also be extended by payment functions and several more modes of transport. However, it is also possible for the IT-platform to be taken over by other operators. However, even if the charging hub does not operate the IT-platform, it should still retain a coordinating role after the development work on the system has been completed, for which appropriate capacities should be made available (Osterwalder & Pigneur, 2010).

7. Key Activities

This section lists the most important directions and measures for implementing the business model and making the business model work. Mobility is currently one of the particularly dynamic fields of experimentation and application of new technologies and media. A profound change in mobility is expected: electrification (e-Mobility), networking (Connected Mobility), automation (Autonomous Driving), sharing (Sharing Economy) and the renaissance of the two-wheeler culture are major trends, shaping this change. Due to these dynamics, a broad spectrum of mobility services unfolds: “A seamless, highly networked and personalized travel or mobility chain across different modes of transport, from intermodal route planning, booking on demand and payment to the handling of journeys” (Ritter & Schanz 2019, p. 230).

The public rarely knows the term “mobility-as-a-service”, but the idea is currently causing excitement among mobility actors, and in research, because it is associated with several expectations and key activities (Jittrapirom et al., 2017). The future charging hub has the potential to provide a platform for all modes of transport, including new ones and familiar ones, such as car sharing. This would give the consumer more choice and allow the transport service provider to improve services, retain customers and attract new customers.

Mainly through the focus group session, experts from various branches, interaction points and front-end processes were identified. The input of experts from other industries, gave a better understanding of what future activities will be needed for the new solution to deliver the expected value. An example of the first key activity is the implementation process, which is necessary to ensure that the customer is able to proceed with electrical charging in its daily operations in a cost-competitive approach, so that the offered value is generated.

The overall approach of the future mobility hub will encourage the use of various transport services by facilitating intermodal travel. The following modes of transport must, therefore, be included: public transport, taxi, car sharing, carpooling, bicycle rental, car hire and on-demand bus services. In order to offer a complete service portfolio in relation to bridge waiting time or the establishment of the charging hub as leisure activity, the following service components can be added to the charging hub portfolio. Additional components to be integrated: restaurant and shopping, billing systems and payment services, mobility planning, parking services, logistics services, payment services, routing services and bicycle boxes and package boxes.

8. Key Partnerships

In most cases, a company needs partners for the successful implementation of a business model. The key partners are identified through the literature research, the interviews and the focus group discussion. Accordingly, the charge point operator or the e-mobility service provider interacts with e-mobility end users and other partners respectively providers.
Partners are, for instance: eRoaming platform-operators, as well as retailers, shopping and restaurant chains, the distribution and/or local network operators, transport providers and energy sales (electricity, hydrogen).
There are contractual and physical relationships between the market players in the form of goods and services, energy supply and data communication. Data access and communication between the market players is regulated for the charging infrastructure in DIN 15118. The public charging infrastructure can be designed as a closed charging infrastructure with so-called stand-alone charging solutions up to an open or interoperable charging infrastructure.

In this way, the mobility service provider is the new and vital role within the future charging ecosystem. Hence, the mobility service provider might benefit from having experts shaping this work. The analysis might, therefore, illustrate the multi-layered commitment and interdependence of various companies as well as the necessity of creating co-operations, alliances and joint ventures in order to be successful as an attractive market player in comparison to the competitors in the public charging infrastructure market (Bullinger, 2004).
In the course of development, strategic allies are relevant who have direct access to central target groups and, if applicable, could invest their own financial and human resources in the system. For instance, it would be a suitable option to integrate the General German Automobile Club e. V. | ADAC in order to reach its members directly and possibly offer them a broader portfolio. In addition, the ADAC will then be able to provide information about its members throughout Germany in a much easier way.
Finally, it is very important to assure an open and modular system from the beginning, so that over time a differentiated and stable mobility ecosystem with different mobility providers and services can develop, so that it provides offers for different target and user groups (Bullinger, 2004).

9. Cost Structure

The block describes all costs incurred to operate a business model. It is composed of fixed and variable costs, economies of scale and economies of scope. Additionally it can be distinguished between cost-driven business models, focused on minimizing costs wherever possible. In order to understand the various costs related to the existing charging solutions, company and research studies were considered, which combine the views of the product and solution owners (for charging services & - equipment). Both variable and fixed costs and the identified cost structure were validated with the product- and solution owners to ensure that it had been understood. The cost structure was kept mostly the same for the future solution, since many of the existing costs cannot be neglected in the future, but a few were unnecessary for the future solution and some new ones were added. The newly added cost model is "value-driven", which means that the focus here is not on minimizing costs, but on delivering benefit to the customer. The high quality of products and services offered can set a filling station apart from the other providers. The cost structure includes fixed costs, such as rent and/or lease costs, energy costs, any license fees, maintenance costs and personnel costs. Other probable fixed costs positions can be IT-infrastructure and application, customer support, sales and marketing, and contract management. Variable costs are incurred for operating materials and the purchase of goods and services (Perleberg & Clausen, 2017).

10. Sustainability – extension of CANVAS clusters

According to the WEF (2018) and the research studies of Ciesielska and Iskoujina (2018), sustainability is defined with three dimensions and suitable measures, addressing the ecological, the social and the economic aspects. The clear focus is on environmental awareness and in parallel embracing the social and economic issues.

Bocken (2014) highlights the economic focus of business model literature. Recently researchers are increasingly dealing with business models linked to social and environmental values (Bocken, 2014). Business model innovations for sustainability are defined “innovations that create significant positive impacts on environment and/or society (p. 44)”. Schaltegger narrows it down even further. According to him and his colleagues, it is about redesigning business models, as an enabler to capture economic value for itself, through delivering social and environmental value (Schaltegger et al., 2016).

Considering this, public charging infrastructure development has profound significance on sustainability. In particular, with regards to the Canvas-approach, Erath (2014) has noted that sustainable business models aim for competitive advantage in the economic and environmental aspect, while at the same time serving a sustainable development for society as well as the organisation itself. Thus, the standard business model Canvas is extended by the category “sustainability” for the intended charging business model framework and the mobility hub. This is the main reason that the related empirical findings of this research project are to identify the crucial aspects of sustainable business models to finally obtain economic competitiveness for the future mobility hub.

Moreover, the sustainability of charging infrastructure business models is beneficial to the electric mobility industry, because a better-developed infrastructure can provide better support facilities and services to electric vehicles. Thus, more and more people will opt for electrical driving instead of fossil-fuel cars. Therefore, the healthy development of the charging infrastructure industry is an important basis for the widespread use of electric vehicles and the reduction of environmental effects on society.

Sustainability is regarded as a new business opportunity to gain competitive advantage (Schaltegger, Lüdeke-Freund & Hansen, 2016).
With reference to Karlusch et al. (2018) this research project is investigating business model innovation via figuring out a sustainable development (Karlusch et al., 2018) and an optimal charging infrastructure. Businesses are, in general, expected to more actively address issues such as financial crises, social inequalities, environmental concerns, material resource scarcity, energy demands and technological progress as part of their focus (Joyce & Paquin, 2016).
This is because the company's motives cannot be just a reaction to regulations or legal enforcement nor compliance to conventional industry behaviours. The need to create modern ecological ways to do business and sustainability-oriented innovation therefore is also reflected within the Canvas-extension for charging and new mobility trends.
In today's increasingly complex and fast-changing environment, business model innovation is critical to the success of industrial and corporate development, and it is also frequently seen as a means to promote the sustainability of electric vehicle charging infrastructure Wirges (2016). Innovating the business model for the charging infrastructure industry is a very complicated process, which creates the opportunity to investigate how a company, its customers and competitors can be affected. Wirges (2016) has also noted that business model innovation is an extension of the business model concept that takes account of the dynamic nature of change and represents an emerging theme in innovation research, being based on today`s conventional charging (BCG | Young & Reeves, 2020).
A sustainable charging infrastructure business case and the associated voluntary environmental activities are linked to corporate economic success. Companies make a real investment in sustainability and, thus, create the core of a business initiative (Schaltegger et al., 2016). The initial result is that the future mobility hub, by offering mobility-as-a-service, encourages road users to use modes of transport other than the car more often, which is ultimately the most effective measure for the transition to an overall sustainable mobility & decarbonisation.

According to the descriptions mentioned above, a business model Canvas was composed. Please see summary in the appendix.

5.2.2 Limitations and premises of proposed business model framework

In relation to the overall research approach, some limitations and premises are to be considered in terms of the intended framework. In the conception phase, it is assumed that users would increasingly form intermodal mobility chains in their daily mobility. However, there are also some risks regarding the influence on actual user behaviour. Additionally, there is the existing possibility that the majority of the customers would instead book only individual means of transport and that only a few opt for intermodal mobile. In a worst-case scenario this could lead to an overestimation regarding the importance of mobility stations where different mobility offers are bundled and made available. Besides, there will also be a central challenge in the future, namely cooperation with public transport companies and the public sector, in general. It is estimated that additional public support will be needed to further establish the full range of multi-modal mobility services. This required support is taken as given in this research and could otherwise lead to certain limitations if it is not available.

Within the context of the proposed business model framework, the overall service logic is of course taken into consideration. However, Ojasalo and Ojasalo (2018) stated that the business model Canvas as presented by Osterwalder and Pigneur (2010) is mainly focused on a goods dominant logic and it is not service-oriented. In service-dominant logic, the company is no longer seen as a producer of value, but instead as a supporter of value. The core of this logic is that value does not exist until the offer is being used by the customer (Ojasalo & Ojasalo, 2018). Therefore, Ojasalo and Ojasalo (2018) created an adaption of the business model Canvas by Osterwalder and Pigneur (2010) to better suit the service logic, named the “Service Logic Business Model Canvas”. The difference to Osterwalder’s and Pigneur’s (2010) business model Canvas is that it is purely service-oriented and includes both the aspect of the provider as well as the customer for each of the nine building blocks presented. Against this background, the limitations of this research project are that the customer perspective and the customer value are taken into account, but not separated in the context of the Canvas model, each in nine different categories.

Due to the risk of revealing sensitive and confidential business information, especially for some listed companies, this study does not involve finance-related information such as specific profit or loss and weaknesses. Nevertheless, this does not affect the overall result and analysis of the business models.

Moreover, this study is limited to Germany and involved only a selection of charging infrastructure experts; and this naturally affects the generalizability of the research.
A further key limitation is that only one survey questionnaire was designed and only five interviews were conducted to identify the business models and their influencing factors; or the focus group merely involves a limited number of participants. Thus, the quantity of data makes it difficult to fully understand the business models and their weaknesses. This limitation also requires the general consideration of saturation.

Qualitative research considers saturation as most important indicator for discontinuing data collection and related analysis. This is decided based on the research already carried out (Glaser & Strauss, 1967 cited in Fusch & Nees, 2015). According to Fusch and Ness (2015, p. 1408) a “failure to research saturation has an impact on the all-embracing quality of the research conducted”. The judgement in research to stop proceeding with further data collection and analysis is based on the researcher’s level of information gained, e.g. within the interviews and the focus group (Fusch & Nees, 2015).
This results in the matter of fact, that this decision could therefore for instance only be made prior to final coding (interviews - thematic content analysis) and category development (focus group - concept map). Assessing at this early stage relates to a framework that is theoretically immature, and that may require considerable adaptations (Fusch & Nees, 2015). So to say, the evaluation of saturation is based on identifying the emergence of new themes, without also assessing the understanding of these themes across the data (Hennink et al., 2017). The first-time identification of a theme in the data-set may not be detailed enough; therefore, additional data could be necessary to fully cover all meanings and to understand “the depth, breadth, and nuance of the issue” (Hennink et al., 2017, p. 592; Strübing, 2018).
In addition in scope of this research project and according to missing clear scientific guidance also the inductive thematic saturation is only based on preliminary information from the interviews and the focus group (Inductive thematic saturation and analysis: Relates to the occurrences of new codes or themes) (Strübing, 2018).

Besides there is hardly no scientific knowledge available about the influence of the focus group format on saturation. Data collection in scope of focus group discussions relates to nondirective interviewing, where participants are very much involved in discussions. This is leading to a different type of data than interviews, especially due to several attendees and spontaneous interaction in a group dialogue (Creswell, 2007). Via this research approach various perspectives are collected and a broad range of topics is emerging. But also with this regards, it is not clear how these elements of focus group discussions affect saturation (Fern, 2001). Moreover, how these special characteristics are in fact influencing the inductive data saturation is not existent in current research literature (Fern, 2001).
Thus, also scientific studies only provide some guidance on sample sizes needed to reach saturation in the meaning of issues in data (Theoretical saturation and sampling: Relates to the development of theoretical categories; related to grounded theory methodology) (Strübing, 2018).
Sample size justifications in qualitative research is only limited. Suitable sample sizes for interviews are often justified in research with pragmatic considerations (Flick, 2014). As well in scope of this thesis theoretical saturation was assessed by the researcher at an early stage. In this context this can also be considered as study limitation. But from the researchers subjective perspective, there is no sample size insufficiency, which is negatively affecting the validity and generalizability of studies’ results (Thorne, 2000).

However, these results contribute to small but novel pieces of knowledge that could represent essential aspects of improving the electric vehicle-charging infrastructure from a sustainable business model perspective, while anticipating new mobility trends.

5.2.3 Contribution to knowledge

In scope of all academic disciplines, the provision of "a significant contribution to knowledge is a major requirement for a doctoral thesis" (Esselborn-Krumbiegel, 2014, p. 4). It can be seen in general "as something which someone else has not done before" and involves a large amount of significance and commitment from the researcher (Avison & Malaurent, 2014, p. 346f; Esselborn-Krumbiegel, 2014).
However, providing significance is not only meaning revolutionary arguments and evidence, or inventing something entirely new. The contribution to knowledge does not have to change the course of a research field, but merely it is obliged to assure a new insight and to expand the current academic discussions. The definition of what constitutes a relevant contribution to knowledge is determined by originality, but also creativity, innovation, practicability and business success are affecting it (Phillips, 1994; Nowotny, Scott & Gibbons, 2001; Facultas, 2014). The uniqueness is very much depending on the research question to be answered and the theories or methods chosen. Framing a certain contribution to knowledge is meant by looking at something in a different way and shedding new light on questions, theories or methods in research (Esselborn-Krumbiegel, 2014; Facultas, 2014). This also includes joining the conversation, claiming stance and argue for it, which also underlines the capability of doing research and growing further (Nowotny, Scott & Gibbons, 2001; Avison & Malaurent, 2014).
Dunleavy (2003, p. 32) considers the contribution as "value-added", focusing on the extent to which starting materials of a particular analysis have been transformed, enhanced or differentiated. Moreover, Esselborn-Krumbiegel (2014, p. 36) derives different knowledge outcomes: "new or improved product, new theory, re-interpretation of existing theory, new or improved research tool or technique, new or improved model or perspective, in-depth study of a particular topic, or critical analysis" (Ellen & Brown, 2019, p. 134-136).

Having said this, there is a far-reaching agreement in research, that a contribution to knowledge is realised through a number of ways. Major examples are as well the criteria for achieving originality of Frances (1976) or Estelle and Derek in 2010 (Delamont et al., 2004). In parallel also Rugg and Petre (2004, p. 14) provide a useful list, showing key factors for originality and significance in research (Facultas, 2014):

1. **"Re-contextualization of an existing technique, theory or model (i.e. applying a technique in a new context; testing a theory in a new setting; showing the applicability of a model to a new situation)**
2. Confirmation and expansion of an existing model (i.e. evaluating the effects of a change in condition; providing an experimental assessment of a specific aspect of a model)
3. Contradicting an existing model or a specific aspect of a model
4. Combining two or more ideas and showing that the arrangement reveals something new and useful
5. **Demonstrating a concept – showing that something is feasible and useful; or that something is infeasible and explaining why it fails**
6. Implementing a theoretical principle – showing how it can be applied in practice; making ideas tangible; how something works in practice; and what its limitations are
7. Providing a new solution to a known problem and demonstrating the solution's efficacy."

Coming from these theoretical explanations, the contribution to knowledge of this research is mainly driven by showing the applicability of the business model concept to a new context and pointing out that the concept is feasible and useful (key factors 1. & 5. | Rugg & Petre, 2004, p. 14).

This research mainly contributes to knowledge by pointing out, that the business model concept is observed and applied, while integrating sustainability as a key success factor. This research is also providing the evidence, that sustainability is the most relevant part of the developed charging business model innovation. Finally, the related key contribution to knowledge offered by this research is a new theoretical business model for an electrical charging hub.
The requirement for a related framework has clearly been identified. Accordingly, there is a need for creating new revenue streams and optimising the existing ones. The figures 21 and 36 are visualizing the research gap and the derived business model framework. The results of the primary data collection led to the empirical evidence that a sustainability focus can result in a profitable charging business model. This should be the basis for an easily understandable business model concept - comparable to the Canvas - assisting charging operators in their revenue creation and diversification activities.
This research (figure 38) demonstrates that new mobility trends and behaviours are major enablers for the required sustainability and leading to the way towards a profitable mobility hotspot.
The future mobility hub will link new services areas and offer on-demand mobility services. The related chicken-egg-problem could be reduced significantly via this additional service-portfolio. This is most relevant, as the development of the electric mobility charging infrastructure today requires investments in a market that will at best be large enough to allow refinancing in a few years. Thus, this thesis contributes as well to the body of service innovation research and the mobility-as-a-service innovation literature. Therefore, this thesis showed evidence-based decisions in service positioning and sustainable business model development from a charging operator-perspective.

However, this research is not only investigating a positive relationship between economic success factors and sustainable business models. The research is also demonstrating new business opportunities evolving in the field of electrical charging and mobility services, which would have remained invisible in a purely profit-oriented approach. Accordingly, the contribution builds upon business model perception and application unifying different sustainability dimensions and transferring the consolidated findings onto a conceptual levelling that facilitates more all-embracing interpretations.
Analytical methods are needed to uncover these real causalities between profitability and sustainability. Therefore, the chosen mixed-method approach of multivariate procedures and conceptual methods is crucial for a successful overall investigation of this topic (figure 38).
The primary data collection also confirms the significant influence of the trend towards new sharing mobility solutions and the sharing economy. However, these exploratory findings (figure 38) have not been developed so far into a theoretical business model framework for electrical charging. This research combines these disconnected points into an emerging, knowledge-based perspective on business model sustainability and the dynamics of electrical charging.

The enhanced concept addresses the conditions for economic success and the resulting perspectives of business models in a sharing economy. The charging hub can be addressed as recent example for “a sustainable business model, which is built in a continuous improvement perspective, embedding both the environmental and social spheres in the business model design” (Schaltegger et al., 2016, p. 108f). Through the possibilities of digitalization, economic, ecological and social goals can be realised in equal measure for the first time - via sustainability excellence for electrical charging solutions.

The research findings complement existing entrepreneurship knowledge by highlighting the role of sustainability in the business-modelling context. The framework encourages scientists and entrepreneurs in making informed decisions, referring to business models.

Integrating sustainability is the only way to open up new future growth opportunities. The investigations in scope of this thesis shaped this argument largely. In order to bring about profitable operation of charging infrastructure in the medium term, the change towards sustainability was specifically turned into an opportunity. Companies that perceive sustainability as an opportunity are in the best position to develop innovations and initiate new collaborations. Through this research work, a proactive and forward-looking business-modelling context was opened up more closely. Visionary companies can thus gain new growth opportunities from the important topic of sustainability. By applying the business model Canvas, the entrepreneurial view is specifically directed internally and a restructuring and transformation towards sustainability is encouraged.

Even in times of financial challenges, a sustainability strategy can generate significant added value. A business model-redesign towards sustainability prevents on the one hand failing organisations from slipping back into old practices and on the other hand, it clearly boosts new market entrants and emerging technologies, like electrical charging technology.

The literature review demonstrates and investigated, that there are no theoretical frameworks to analyse this key process and there are no models to show how it works explicitly for electrical charging. This focus on the sustainability of business models is different to existing literature about electrical charging, which mainly tends to envision the creative processes required to generate economical change.

This research builds from existing business model-theory, describes a model for future charging hubs, and outlines opportunities to extend new mobility trends and behaviours beyond economic profitability into the broader category of sustainable transformation. It is substantial to offer this theoretical perspective on how sustainable business model innovation occurs, to transform current electrical charging hubs and to assure a turnaround towards sustainability via the developed business model Canvas.

Moreover, despite numerous sustainability-related instruments, only a few relatively recent approaches can be identified for the business model development phase. Thus, the integration of sustainability aspects into the actual business model development has so far been inadequate, both in literature and in practice. There is a clear need for extended applied concepts, supporting a sustainability-oriented business model development, as the characteristics of such a solid sustainable business model, should provide clear guidance to the company for addressing sustainability issues (Schaltegger et al., 2016). Therefore, this project contributes in particular to the acquisition of new scientific knowledge via the applied business model concept and gained experiences.

Against the background of the future charging station "the mobility hub", the concrete Canvas development is forced, taking into account the individual objectives and the application contexts, as well an orientation towards specific guiding approaches of the sustainable electric charging station. Finally, the sustainability focus was integrated successfully, via the elaborated charging business model Canvas. Via this derived business model Canvas, both sustainability and economic success are reconciled. To achieve this thoroughly, a well thought-out planning and implementation approach was developed. This enables practitioner`s to proceed optimally, as sustainability-oriented charging business model deployment require an early and systematic consideration of sustainability aspects. Sustainability-specific issues already have to be taken up and considered during the development of individual business model elements.

The derived contribution to knowledge is as well, that the integrated participants from industry, research, academics or consulting differ in their understanding of the business model, its awareness and implementation. The literature mainly focuses on more general business model application.
The research enhances knowledge by identifying that the various stakeholders are very diverse in their understanding, perception and application of business models. The different participants contribute with new ideas and viewpoints based on their own observations and reflections. The derived theoretical business model was further elaborated, by using cross-industry examples from the expert practitioner interviewees or the focus group participants. Participating charging operators only rarely apply innovative concepts in their daily business, nor are they broadly informed by theoretical approaches from literature. Because of this, also the significant conclusion is arising, that without challenging existing or new business model concepts via different participants, transformational change cannot be achieved.

The developed business approach for the future mobility hub is a perfect example for business model-sustainability, as its environmental and social components are definitely as relevant as the economic one; see also derived Canvas (appendix). Therefore, it will follow a theoretical attempt to classify the business model of charging stations according to the scientific categorisation approach below (sustainable business model archetypes) (figure 41) (Boons & Lüdeke-Freund, 2013).
Ritala (2018) developed sustainable business model archetypes based on a comprehensive literature and practice review to the design of business model innovation for sustainability. These nine archetypes are divided across environmental, social, and economic categories as the major innovation types. With these architypes the contribution of the developed business model framework “for the future mobility hub” to sustainability research can clearly be illustrated.

Figure 41 | Sustainable business model archetypes (Bocken et al., 2014; Ritala et al., 2018)

Environmental	**1. Maximize material and energy efficiency** 2. Closing resource loops **3. Substitute with renewables and natural processes**
Social	**4. Deliver functionality rather than ownership** 5. Adopt a stewardship role 6. Encourage sufficiency
Economic	**7. Re-purpose for society/environment** 8. Develop sustainable scale-up solutions 9. Inclusive value creation

Derived from literature and the primary data collection process, the empirical investigations indicate that a charging business model can only be successful via a commitment to overall sustainability. The first sustainability-pillar of the defined charging business model framework is the integration of new mobility trends and behaviours. According to Ritala`s archetypes, sustainability is successfully assured via delivering functionality aspects rather than ownership and, especially, taking into account shared mobility (Social | 4. Deliver functionality rather than ownership) (figure 41).

The other initial results point to the future mobility hub-offering mobility-as-a-service, encouraging road users to use modes of transport other than the car more often, which is ultimately the most effective measure for the transition to sustainable mobility (Environmental | 1. Maximize material and energy efficiency + Social | 4. Deliver functionality rather than ownership) (figure 41).

The sustainability of charging infrastructure business models is, of course, also given due to their benefit for electric mobility penetration, because a better-developed infrastructure can provide better supporting facilities and services to electric vehicles. Thus, increasing numbers of people will opt for electrical driving instead of fossil-fuel cars (Economic | 7. Re-purpose for society/environment and environmental | 3. Substitute with renewables and natural processes) (figure 41).

The key focus of the framework “enabling electrical driving” is that by providing suitable public charging solutions the integration of renewables and sufficiency approaches are addressed, in particular, in case of a linkage to the power grid, to demand management and to balance fluctuating wind and solar energy (Environmental | 3. Substitute with renewables and natural processes).

The archetype “Re-purpose for society/environment, instead, seeks to maximize the positive societal and environmental impacts of the firm on society by, in this case, considering a social infrastructure and the need to provide charging facilities, also in less-frequented or rural areas. Therefore, the healthy development of charging infrastructure is an important basis for the widespread use of electric vehicles and reducing environmental effects on society (Environmental | 7. Re-purpose for society/environment) (figure 41).

Via this extensive and innovative research about electrical charging, some new knowledge based on the previous available sustainability knowledge is created. Canvas-related theory, empirical findings and the application of Ritala`s archetypes, contribute to the understanding of sustainable business models. This scientific anchoring of business model sustainability and the related enrichment of the business model Canvas for the future filling station make this research project unique.
Relating thereto, this research project clearly states that the development of a sustainability-oriented charging business model can be successful. Hence, sustainability efforts have to be appropriate and have to be linked suitably to a specific business example. Otherwise, economic return (Ciesielska & Iskoujina, 2017) would not be possible in parallel. This goes along with this research, stating how sustainability innovation can be an important pillar of a profitable mobility hub-business model design.
Schaltegger also emphasizes the evolving necessity of a sustainable business model design. Such a design is putting charging operators in the positon of capturing economic value for itself, via delivering social and environmental value to a wider set of stakeholders (Schaltegger et al., 2016; Karlusch et al., 2018). In this perspective, sustainability is considered as a new business opportunity to raise the future charging station`s value proposition via business model innovations, focusing on those changes towards an all-embracing sustainable development.

Companies inevitably have to address the sustainability agenda in the light of changing consumer expectations, if only to secure the future of their business. This found expression in the 17 Sustainable Development Goals (SDGs) of the United Nations (UN), and in scope of them companies - along with government and society - are seen as playing an essential role in the transformation, from financing to developing sustainable products and services (United Nations, 2020). Such approaches have already enabled a number of companies to achieve greater sustainability in practice as well as to establish new and profitable business models (ERM, 2021).
Sustainable business models help to successfully position enterprises and to introduce technical innovations to the market. Offer high customer value added is crucial for a sustainable business model, as with the combination of electrical charging and new mobility services. The path to sustainable business models is not the easiest, but it is worthwhile (ERM, 2021). The transformation of business models often involves a fundamental change in the previous views of the customer offering, of processes and of the resources applied. Thus, a profitable and sustainable business model should also be brought about in the area of charging infrastructure through fundamental change, even if the future of new mobility is difficult to predict.

5.2.4 Business path, unique implications and contribution to practice

The provision of integrated transport services is not new. However, the new mobility- and charging hub differs in several ways from existing transport concepts, such as integrated transport or multi-modal mobility.
There are three elements to be highlighted, which distinguish it from other concepts, namely:

- the emphasis on personalisation and future mobility trends and -behaviours,
- the reliance on digitisation and
- the business dimension, meaning, in particular the combination with charging solutions for the future fuel mix and electric mobility.

Existing approaches also stress the potential to combine transport services with services from other sectors such as entertainment, tourism or restaurants. Nevertheless, the concept of a new mobility hub focuses on the user, people or goods and offers mobility solutions tailored to individual needs. This means that easy access to the most suitable means of transport or service is included in a package of flexible mobility offers for the end consumer.
In this context, it is very important to ensure an open and modular system from the beginning, so that over time a differentiated and stable mobility ecosystem with different mobility providers and services can develop, which guarantees offers for different target and user groups. The central factor in the implementation and sustainable operation of a mobility hub concept is the business model, which varies in the respective applications. Common to all business models are certain key activities, partners and resources and, of course, the aligned overall value proposition. This is summarized in the sustainable business model, developed in scope of this research (see appendix – Business Model Canvas).

Numerous public transport companies, transport service providers and Internet groups such as Apple, Google and Uber, as well as numerous start-up companies, are working on new mobility services and are trying to realize the vision of ad-hoc networked, environmentally sensitive and autonomous vehicles. In the meantime, all established vehicle manufacturers have jumped on this development. Numerous new business models are emerging in the area of mobility sharing (free-floating sharing, peer-to-peer sharing, ride sharing, etc.), and in the area of on-demand services. Pioneers in linking mobility services in context of mobility and charging hubs are expected to enter the market soon. Then the future charging hub will successfully combine different modes of transport, such as public transport, taxis and car rental services. Thus, it is encouraging private car owners to consider in parallel new alternatives for car ownership.
On-demand shared-mobility services as well needs to make sure that public transport is becoming a widely appealing alternative to private mobility. For a significant reduction in private cars, people have to be increasingly encouraged to use public transport; also by means of subsidizing trips to mobility hubs. Efficient and flexible public transport is required, also to compete against competition from private mobility services.

Nowadays customers have increasingly adopted new mobility possibilities and this is leading to greater use of shared mobility services. Transport operators have also started to enrich their service portfolio. Though, for shifting towards an integrated mobility approach, mobility-as-a-service- and data-providers also have to enter the changing market.

“However, mobility-as-a-service is far from being achieved” (IRENA, 2019, p. 75). The topic “mobility hub” will require significantly further analysis and an enlargement of the so-called serviceability. This is the clear prerequisite in order to convince traditional car owners to decide upon giving off their personal vehicles, as shared mobility fulfils all their needs and requirements.

Mobility modelling and data availability about mobility patterns and behaviours, are necessary along with the development of a comprehensive transport operators’ portfolio. Travelers must be able to transfer seamlessly between different modes. Only when assuring nearly the same comfort, avoiding delays and assuring general reliability, passengers are considering this as an equal mobility alternative. It is to be ensured that all users are finding easily and in a timely manner the perfect-matching ride. To realize this vision, the emergence of new players is essential. Investing in more mobility hubs is of high importance; where travellers are going in the same direction and can access shared transportation easily. These large transit facilities at critical nodes are also offering additional services with dining and shopping options to assure an overall sustainable business case. It is to be considered, how such a transition towards wide-ranging mobility-as-a-service offerings could be realized so that its benefits are maximized in line with local priorities.

CHAPTER 6 | CONCLUSION AND OUTLOOK

The existing area of conflict between low profitability of charging stations and the need for adequately developed public charging infrastructure must be monitored continuously in the future. Overcoming the so-called “chicken-egg-problem” and cost reductions, combined with profit improvements, have to be considered in the medium term. It should be noted that the interests of the listed stakeholders are also influenced by changing technical and socio-economic conditions over time. Therefore, these objectives should be checked for appropriateness at regular intervals.
Changing framework conditions naturally also influence the underlying business models for operating a charging station. The assessment of incentives for user- or operator behaviour must also be constantly monitored in this respect particularly due to the high impact of political decisions on that topic. Accordingly, there are several possible future research areas, which would need investigation to follow-up and build on this study. The exploration of a sustainable business model for charging solutions is an ongoing effort.

An important point is that to overcome the negative impact on profitability, customer experience and the gradual transformation of the charging station towards a mobility hub need to be improved. Thus, charging operators are leveraging their service portfolio with multi-modal mobility offerings. However, only some key areas could be investigated in this study. Electric mobility, new mobility trends and charging infrastructure are a new, complex and very dynamic research area. “There is currently no common or clear vision for how the design and deployment of the required infrastructure would be affected by changes in mobility patterns, vehicle technology or energy systems” (WEF, 2018, p. 7).

Therefore, it is worth exploring in much more depth the manifold factors influencing business model sustainability of a future charging hub as an ongoing ambition.
The public charging infrastructure assumes a key role in the change towards sustainable mobility. Visibility and comfortable usage, as well as technological maturity, contribute to the acceptance of electric mobility solutions. The public charging infrastructure cannot only achieve profitability through new mobility trends, but can also be a link between end users, the newly emerging mobility value chain, and adjacent business areas. “The mobility sector will have to be at the forefront of the transformation of mobility patterns, developing new business models based on service and sharing models, rather than ownership and personal use of vehicles. At the same time, mobility players will have to consider the opportunities created by new uses and services associated” (WEF, 2018, p. 22).

Certain studies are researching the new generation of multi-modal mobility, leading the transition to a low carbon new mobility era in a sustainable manner (UCL, 2019). Mobility-as-a-service is an approach, which integrates current and future mobility trends (Garcia et al., 2019), but the current state of the art regarding mobility-as-a-service ecosystems is fairly limited.

According to Garcia, this includes electric mobility systems (such as electric vehicle-fleets and charging points, etc.) and shared electric mobility services (such as e-car sharing, e-bike sharing or e-scooter sharing, and even extra mobility modes such as e-public transport or demand responsive transport).
Although the number of shared mobility, electric mobility and multi-modal passenger transport users is rapidly growing, until now there have only been a few mobility-as-service-providers available (Garcia et al., 2019). As mobility-requirements will further develop, the business model scenarios also have to be further investigated in the light of new mobility services (Pfaffenbichler, 2017; UCL, 2019).

This recommended business model assumes that the consumer places a very high value on multi-modal services and that the customer prefers to consume these services at a filling station, which is not the case at the moment. The model is, therefore, dependent on a paradigm shift in what is anticipated and what a future charging hub is expected to be.
“All stakeholders must cooperate to ensure a seamless customer experience, by supporting the deployment of a flexible, open and multi-service infrastructure” (WEF, 2018, p. 22.)
The aim of developing a sustainable business model innovation for the future charging hub has been fulfilled by the present research activities. This, initially, quite broad task could be systematically researched thanks to the Business Model Canvas to Osterwalder and Pigneur (2010). The model developed was elaborated based on future mobility trends and, therefore, offers starting points for further considerations and even possible solutions to the current problem (Pfaffenbichler, 2017).
“Finally, according to McKinsey, these changes towards mobility-as-as-service could have profound economic and social effects. McKinsey analysis indicates that in 50 metropolitan areas around the world, home to 500 million people, integrated mobility systems could produce benefits, such as improved safety and reduced pollution, worth up to $600 billion (McKinsey, 2018a, p. 9ff; McKinsey, 2018b)”.
Given innovation trends in mobility, it is realistic to envision a future scenario in which people in a smart city enjoy a wider range of affordable, on-demand, multimodal mobility options, traditional cars and ownership practices will be replaced by shared electric- and autonomous vehicles. Area-wide electrical charging and associated new business models in terms of profitability and sustainability are then part of a comprehensive mobility ecosystem.

APPENDIX

CHAPTER 2 |
RESEARCH BACKGROUND, ELECTRIC MOBILITY AND CHARGING

2.2 Object of investigation – clear need for public charging infrastructure in Germany

2.2.1 Overview of charging applications

CHAPTER 4 |
RESEARCH PHILOSOPHY, METHODOLOGY, STUDY DESIGN

4.2 Impact of chosen research philosophy on research strategy and design

4.2.2 Usage of methods, pilot study experiences and data equivalence

FURTHER ATTACHMENTS

- **Primary data collection – attachments**
- **Research Conference 2020 – poster Judith Karl**
- **Business Model Canvas | derived business model framework for a public charging station – the future mobility hub**

2.2 Object of investigation – clear need for public charging infrastructure in Germany

2.2.1 Overview of charging applications

Overview of charging applications

Battery-driven vehicles | BEV and related battery charging technology

Regarding literature for charging infrastructure, a distinction is made between private, semi-public and public charging infrastructure for battery-driven vehicles.

The private charging infrastructure initially comprises the charging infrastructure for private customers, i.e. car parks and parking spaces in detached houses or apartment blocks (Wildemann, 2018). There are several providers for this and, hence, options for customers to choose from, thus several business models for the different customer groups. For private customers, charging stations “wall boxes” are offered at similarly low prices, as they can be easily integrated into the existing power grid. The sale and operation of private charging facilities to residential customers is of great economic interest to regional energy suppliers as they already have a large customer base and a billing system that works for commercial customers due to their traditional activities (Proff et al., 2013). By using wall-boxes, they would be able to increase the loyalty of private customers, sell more electricity to their customers and thus increase sales and profit. This is why the concrete design of this business model in connection with additional services and the benefit promise are not of particular interest for this research project (Klima Allianz Deutschland, 2016). Private charging infrastructure is used not only for private customers but also for commercial customers who require charging facilities for their own commercial vehicles | fleet or loading facilities primarily for employees at the company's premises. In semi-public areas, the charging stations are used, for example, on parking lots or in underground garages of hotels, shopping centres or car parks for their customers (Klima Allianz Deutschland, 2016). Charging stations for public areas are set up by energy suppliers and charging operators e.g. alongside motorways and connected directly to the public power grid (Proff et al., 2013).

In relation to recent technical research studies, there are three basic options for recharging a battery-driven electric vehicle: wired, via induction and by swapping batteries. The focus will be set on wired- respectively conductive charging, since this is currently the most used solution, which is commercially available. Against this background, Bräunl highlights the differences of charging power (Bräunl, 2013). Charging power defines the time required to charge a battery-driven vehicle (Hall & Lutsey, 2017b). This can vary by orders of magnitude across charging point solutions. A small private wall box may charge as slowly as 1.2 kW, while the most advanced rapid charging stations can charge at up to 400 kW (Wildemann, 2018). In many cases, the reality is that some electric vehicles are limited by the maximum charging power they can accept. (Bräunl, 2013). Because fast charging processes also have stronger negative effects on battery lifetime, researchers assume that fast charging is mainly used during long distance trips (Jochem et al., 2015).

Fuel-Cell vehicles | FCV and related hydrogen charging technology

A hydrogen filling station has one or more fuel pumps with which the energy supply of mobile hydrogen consumers, usually fuel cell vehicles, can be replenished (Wildemann, 2018). For many years, science and industry around the world have been conducting research into the technical use of molecular hydrogen (H2) as an energy carrier. It is recognized, that H2 is an important contribution to the decarbonisation of the energy systems, previously dominated by fossil fuels, even if there are still technical and economic challenges to overcome.

Hydrogen is a widely used industrial gas for which extensive operational experience is required to ensure a safe and reliable operation. Besides, the use of hydrogen as a source of energy and as a fuel is a system innovation (Klima Allianz Deutschland, 2016). The specific physical properties of hydrogen and its relatively low volumetric storage density represent a challenge for future supply systems. Due to these properties, hydrogen is suitable for usage and storage as a source of energy in both stationary- and mobile applications. This is done by compression, liquefaction or also by direct feeding into the existing natural gas network as a storage option for balancing fluctuating electricity fed into the public grid (Klima Allianz Deutschland, 2016). For example, hydrogen is produced in order to store it in the existing natural gas infrastructure and to supply it with a time delay or directly to different sectors of use e.g. the electric mobility sector.

The decentralized generation of H2 immediate refuelling on site at the filling station is also a promising option. One major possibility here is the conversion of renewable electricity into renewable gas via electrolysis | Power-to-Gas. Followed by the endeavour to bring fuel cell technology to marketability over the coming years, innovations in the field of promising high-temperature electrolysis offer the possibility of the best possible results (BMWI, 2018). The related R&D-recommendations mentioned in the report "Energy Technologies 2050" (Dallinger & Wietschel, 2011) have only been partially implemented; meaning e.g. the continuous improvement of fuel cell vehicles and hydrogen technology is still underway. The individual electrolysis technologies, however, are in very different development stages. Some of them are still in the R&D-stage; others are almost marketable technologies in demonstration operation (Themaa et al., 2018). The major element here is also the construction of several hydrogen charging stations to lay the foundations for a nationwide hydrogen infrastructure (Klima Allianz Deutschland, 2016).

Certain technical components are necessary for the construction of a hydrogen refuelling station (Dallinger & Wietschel, 2011). For all refuelling stations, this includes storage facilities for hydrogen, compressors to bring the hydrogen to the required gas pressure level, a precooling system, and dispensers for delivering the fuel (DLR & ARAL AG, 2019). Depending on the type of system and chosen distribution path, the compressed H2 is either temporarily stored in gas form in high-pressure storage tanks or fed directly to the fuelling system. This also integrates the possibility of having an electrolysis plant available on site.

Primary data collection – methods used, description and key lessons

Semi-structured interviews	• Why semi-structured interviews at the very beginning? • What are the interview guidelines and the interview processes? • What are the key-lessons from interviews?
Survey	• Why a survey based on expert interviews? • What are the survey guidelines and the survey processes? • What are the key-learnings from the survey?
Focus group	• Why a focus group session at the end? • What are the focus group guidelines and the focus group process? • What are the key-lessons from focus group?

The interview

Why semi-structured interviews at the very beginning?

These interviews were mainly used to gather focused, qualitative textual data. The main purpose of this first approach was to simplify aims and objectives and to concentrate on the main pillars of current research discussions. Particularly concerning this very new research area, the focus within the first step was on the specialist knowledge of the available experts. Using this qualitative measure, the nature of the charging infrastructure was explored. These semi-structured interviews are a qualitative method of inquiry that combined a pre-determined set of open questions with the opportunity for the interviewer to explore particular themes or responses further (Denzin & Lincoln, 2011). According to Oakley, qualitative interview is a type of framework in which the practices and standards are not only recorded, but also achieved, challenged, as well as reinforced (Oakley, 1998).

Questions are kept open and flexible to inspire respondents to elaborate on their experience without any restraints, which allows new and interesting insights to be pursued (Frey, 2018). In this way, some initial guiding questions or an interview core concept was prepared in advance. However, there was no formal structured protocol, used to move the interview conversation in any direction of interest that may have come up.

Therefore, a semi-structured method was the optimal way to address specific points, and on the other hand, provided enough flexibility for the experts` voices (Denzin & Lincoln, 2011). This was because unstructured interviewing involves direct interaction between the researcher and a respondent.

The advantage of more open procedures, however, is that the respondent's answers show how he or she understood the question." Thus, the interviewee is guided, to indicate what is relevant to him in what way. Closed questions do not reflect the complexity of cognitive structures at all (Kohli, 1978).
To achieve optimum use of interview time, interview guides serve the useful purpose of exploring many respondents responses more systematically and comprehensively while keeping the interview focused on the desired line of action (Oakley, 1998). The order of the questions and their exact formulation are generally up to the interviewer. The interviewees' answers should be as detailed as possible; aspects addressed by them should be as comprehensive as possible (Corbin & Strauss, 1990). Based on the interview process and the results obtained from the interviews with this small number of experts (5), the following survey questionnaire was designed. Using the interviews as a kind of a pre-check, it was possible to narrow the topic down to the main aspects and to design and use the intended survey questionnaire much more effectively (Frey, 2018).
The content of the interview questions is mainly derived from literature and reflecting all described parameters of the topic and the overall research approach. Thus, the McKinsey-study (McKinsey, 2018a), the Wildemann-scenarios (Wildemann, 2018) about electric mobility and the theory behind sustainable business models (Boons & Lüdeke-Freund, 2013) influenced the interview questionnaire.

What are the interview guidelines and the interview processes?

Of great importance for the interviews is the timing and the environment. Both aspects have to be scheduled effectively (Bühner, 2011). The interviews were held in person - face-to-face or by Skype-video chat. In terms of the interview settings, the start was a brief introduction to the interview partners and the study, and the importance of the person`s participation was emphasized. This was especially necessary in order to establish the line of communication and to evoke thoughtful answers from the interview partners. At the beginning of the interviews, the ethical considerations were highlighted, in terms of the related premises and confidentiality and anonymity, as well as a clear feedback-loop to the interviewee (Bühner, 2011). Against this background, it was also very important to keep in mind that interview answers should always be considered with regards to the context in which they were gathered (Flick, 2014). Also necessary was being aware of related bias issues and their consequent avoidance with regards to the promised objectivity. Interview bias can occur during the interview design, the interviews itself or during data analysis. In general, bias is possible during any phase of research, including the study design. As some degree of bias is nearly always present in a published study, the researcher, therefore, has to consider in general, how bias might influence the study's conclusions (Frey, 2018). It is important to be especially aware of the unconscious biases, which indirectly influence an interview process (Morgan, 1998).
Based on this understanding, these recommendations were integrated to avoid bias in terms of the interviews and the main pillars of the primary data collection process.
Interviewer bias could, for instance, influence the way in which questions are asked and responses are given. Such bias may stem from perceptions of the interviewer's identity, or the degree to which a link has been established between interview partners. Alternatively, interviewer bias may be due to body language or other paralinguistic aspects of communication.

By concentrating on these issues, the interview partners were addressed in a fair and ethical way (Frey, 2018). In the context of the interviews, the interpretative paradigm also comes into effect. Rosenthal describes this as follows: People are not understood as organisms that react to their environment, but as acting and recognizing organisms that create social reality through their own actions and interaction with others. It is, therefore, essential that the course of the interview is oriented towards the statements of the interviewee. The interview should establish social reality through interaction between the interviewer and the interviewee and not allow existing knowledge to drain away through "right" questioning. This is because such knowledge does not exist per se, but only in dependence to the situation and the way in which the subject is approached. According to Rosenthal, guideline-based interviews are always oriented, at least implicitly, to the quality criteria of standardised interviewing. However, this does not work per se, since the same language symbols (= same question text) do not have the same meaning for everyone. Accordingly, an interview has to be based on the language codes of the respondents. This works most effectively if as few questions as possible are formulated in advance (Kötter, 2008).

Based on the literature of the secondary data collection process, a draft of the short, semi-structured questionnaire was made. This interview questionnaire was presented in advance to one expert in that area of research and, in parallel, to one researcher, in order to have a kind of pilot test. The pre-test with a researcher, who has already gained experiences with scientific interview approaches, was of great importance. Afterwards, the interviews were conducted with improved interview instrumentation. This is especially necessary for good quality about data analysis and deriving further conclusions. Besides written notes, this was assisted via audio reporting in order to avoid information losses. All the relevant information regarding the experts` background was recorded; for instance education, professional experience, etc. (Morgan, 1998).

When designing the short interview questionnaire, the start is a brief overview of the main research questions of this area of study and their related areas of knowledge. Based on this outline, the questions are defined for each major area, directly addressing the interview partners and their experiences and their expertise. Besides this, the question design takes into account a very open format of questioning in order to obtain wide-ranging and honest answers from the interview partners. This is especially achieved by asking questions with “how?” or “why?” The selection of the limited number of experts for this interview will follow according to these main criteria: “Who has the relevant information?; Who is accessible in the medium term?, Who is willing to give the relevant information?; Who is most able to give the relevant information (Mayring, 2002)?

What are the key-learnings from interviews?

With regards to the interviews the pilot-testing was carried out with one expert, working in the same company as the researcher. This colleague confirmed that the intended questions make sense and lead to the main pillars of the following research approach or the respective focus areas “electric mobility and charging”. Within this test, it was crucial, to emphasize the launching point much more and to highlight very clearly the relevant information for the research approach. This also allows the interviewee to understand where the interviewer thinks he or she is matching and can especially contribute via specific background. In addition, the recommendation was given during the pilot testing that the interviewer should be careful during the interviews not to react after receiving answers. Therefore, it was always important to keep in mind that the interviewer must respond only with a uniform, polite interest. The recommendation received from the university professor, who is very much involved in various interview approaches against the background of his studies, was mainly driven by a clear target-description of the first interview session. The data collection within the interviews should be used as an early pilot, were the main pillars are evaluated in a purely exploratory approach. His recommendation was to highlight that very clearly at the beginning of the analysis.

The survey

Why a survey based on expert interviews?

In the process of research design, the “participatory” methodological approach is used. This is an enabler via considering the input from participants when developing the sustainable business and operator model, also with expertise from various industries. Business models enabling electric mobility and public charging should, in particular, also be encouraged by other practical examples in various branches, where this trend has already been realized (Leisen et al., 2019). Therefore, digging into other industrial areas with new technology was of high importance, for instance, operator models for the use of 3D-printers (Leisen et al., 2019). In this context, it was required not to concentrate only on a small group of experts (first interview approach). The idea was to “roll-out” the data generation to other branches with much more experience in sustainable business models. A survey is capable of collecting data from a large number of respondents and the intention was to use multiple sources and a widespread survey, in order to maximize understanding for the specific research question. In this way, a broad range of data could be collected. Gathering information from many individuals was helpful for generalizing and was an important basis for the following focus group and the associated in-depth analysis. This process, and drawing on various sources and perspectives, is also called “triangulation” (Braun & Clarke, 2006). Another advantage is of this technique is that standardized surveys are relatively free from several types of errors.

Surveys are easy to develop, especially when using the advanced survey software solutions available today. The reason for this survey approach was also the intended analysis of new mobility trends and behaviours and, in parallel, their influence on a sustainable public charging business case. The accurate survey data provided insights that were obtained directly from an individual. These data were inherently more reliable in terms of the motives behind certain actions and changing behaviours. Surveys, in general, provide honest responses, especially when it is clear that the answers given will be kept confidential.

What are the survey guidelines and the survey processes?

With the input of the semi-structured interviews, a web-based survey questionnaire was designed, in order to quantify people's attitudes. The design of an online survey requires several decisions on how to structure the questionnaire that directly affect the respondents` willingness to participate and the quality of the data obtained. Questionnaires sometimes have a bad reputation and over recent years, the response rates have been declining. Therefore, it was also emphasized in the questionnaire that the participation and individual user experience are very helpful for the related research project.

The decision was made to choose an online survey in order to approach several participants in an efficient way. Advanced survey software solutions have multi-mode capabilities for online surveys, mobile surveys, email surveys, paper surveys, kiosk surveys and more; giving researchers the ability to survey even the hardest-to reach participants. While taking an online approach, the design and structure for the questionnaire was extremely important. The reason is that this new data collection method varies from other methods, for example a face-to-face interview or an interview by phone. By using an appealing survey design, it was intended to gain and to keep the interest of the participants (Cavana et al., 2001).

The survey questionnaire had an appealing design in that the questions were clearly formulated and easy to read. Coming from this innovative research environment a pleasant and future-oriented design was of high importance. An interactive systematic was comprised interactive sections that explained the question and provided some background information, always giving the interviewee the impression that someone is talking to him / her. This online questionnaire was distributed via e-mail and was send out via a related link to potential respondents.

During an online survey, it is of course much easier to simply close a tab, than to ask an interviewer to leave and disrupt the interview process, despite a half-finished questionnaire. During a web survey, it is impossible to directly address the interviewer, when having difficulties in understanding certain questions or when having technical problems, e.g. if the webpage does not load. Thus, the question layout and formulation could be even more important than in a face-to-face survey. Besides this it is was also essential to bear in mind that web surveys are increasingly being completed via using tablets and smartphones, which are not comparable to average PCs, e. g. these devices are portable and have touch-screens (Cavana et al., 2001). Due to these changes, an appealing layout for mobile devices was implemented.

Before beginning the development of this survey questionnaire, the target picture is summarized for the research intended to capture via the questionnaire. Afterwards this overview is the basis for the questionnaire design (Creswell, 2014). The intended questionnaire checklist is a list of statements, for which the researcher is looking for. These hypotheses were derived from the interviews and the literature research. Either the survey participant simply checks whether each item on the list is true or not. This proceeding should underline the inductive aspects within this survey approach, meaning a hypothesis based on existing details is developed and then a research strategy is designed to test the related hypothesis via the online survey. Accordingly, a hypothesis is a supposition or explanation made based on limited evidence as a starting point for further investigations (Mayring, 2002).

Inductive means reasoning from the particular to the general. If a causal relationship or link seems to be implied by a particular theory or case example, it might be true in many cases. An inductive design might test to see if this relationship or link did point to circumstances that are more general. This hypothesis is put to the test by confronting it with observations that either lead to a confirmation or a rejection of the hypothesis (Mayring, 2002). In connection with the hypothesis testing it was decided to choose a set of structured questions with pre-defined answers. This type of questions enables a common data collection and analysis with limited time constraints. By applying so-called rating-scale-questions, the respondents had the possibility to assess the hypothesis based on some given dimensions. In comparison to the interviews, the research intention was summarized at the very beginning. A short instruction at the top of the survey questionnaire was also integrated if required for specific questions. The questions were prepared with clearly stated wording in order to avoid misunderstandings.

Once the survey questionnaire was developed, a small pilot test (2 people) was conducted to make sure that respondents clearly understand the questions asked in order to capture the information needed for the study (Mayring, 2002). It is always necessary to ask oneself and other people whether the concepts to be measured statistically are really measured by the way the questions are formulated. It is also required to control for the correctness of all routings in the questionnaire. This is especially important in web-assisted data collection because otherwise the respondent or interviewer can be guided completely in the wrong direction, which normally leads to incomplete responses (Mayring, 2002).

What are the key-learnings from the survey?

The important feedback from the pilot test led to an overall reduction of the number of questions. The pilot participants made the interviewer and the researcher aware of the fact that a rather lengthy survey may be unhelpful. Asking for mutually exclusive answers and avoiding redundancies is extremely important. The point was to concentrate on the wording for the questions, which was clearly asking for the desired answer. In addition, a major key learning compared to the interviews was the helping anonymity. In relation to details about internal business models – also a USP | unique selling point – excellent answers were given to sensitive questions and the likelihood of receiving answers could, therefore, be successfully increased. Thus, the response-rate was high. Therefore, in this way, issues of self-selecting bias were successfully handled. Self-selecting bias means that not everyone receiving the questionnaire is really returning the survey. In addition, those who handed the completed questionnaire back may have specific attitudes, attributes or motivations that are unlike those who did not take part in the online survey.

To summarize, this is an excellent research technique used to collect sensitive information, supplementing the interviews and the focus group with clear advantages of spontaneous responses and adding additional information. It provided the opportunity to explain questions during interviews or the focus group was extremely appropriate.

The focus group session

Why a focus group session at the end?

Qualitative data collection methods play an important role by providing information useful to understanding the processes behind observed results. Due to this, qualitative methods could be used to improve the design and quality of survey-based quantitative evaluations by expanding or clarifying quantitative evaluation findings. This explanatory sequential design typically involves two phases: an initial quantitative instrument phase, followed by a qualitative data collection phase, in which the qualitative phase builds directly on the results from the quantitative phase. In this way, the quantitative results were explained in more detail through the qualitative data (Frey, 2018). Creswell et al. (2007) explain that this design approach is very straight-line. On the other hand, scientists have to bear in mind that the real assignment is quite difficult and certain methodological issues have to be considered. Referring to Creswell (2007), one of the most important issues in this study was to assign priority or weight given to the quantitative and qualitative data collection and analysis. The stages in the research process at which the quantitative and qualitative phases are connected and the results are integrated also had to be taken into account very carefully. These points are discussed very heterogeneously in the research literature and there is no uniform approach. There is only a situational recommendation - depending on the individual case (Creswell, 2007).

Therefore, after the quantitative evaluation, it was continued with a sense check with a focus group (12 participants). Within this approach, the business model developed and the gained quantitative data analysis were presented to them, adding their practical view to the results obtained. Their practical expertise was a sense check of theoretical hypothesis and the model, and this integrates a realistic view on how the developed model performs in daily business (Greenbaum, 1998). Focus groups are similar to semi-structured interviews in being conversational and informal. Both methods allow an open response from the participants, but focus groups explore the subject from many more angles. The difference between semi-structured interviews and focus groups is that the interview only enables interaction between the interviewer and the interviewee; the focus group discussions foresee much more interaction and different opinions can be erased and can captured. In particular, this group interaction may encourage participants of the focus group discussion to make connections to certain issues through the discussions that may not occur during individual interviews. It was extremely important, that the researcher considered the issues in advance in terms of whether the focus group was a suitable research technique with regards to the overall research goals; and the researcher was not using this approach only because it is considered an innovative research method (Creswell, 2007). Focus groups are often the opportunity for researchers to dig into very new research areas and to find, especially, orientation via fruitful discussions (Crowther & Lancaster, 2008).

This is particularly due to expert panel and by combining their business expertise; this technique was used to test their reaction to this upcoming topic as an element of a company’s new strategy. One of the main advantages of this technique was that the invited experts also had the possibility to reflect or react to the viewpoint of others and, via this proceeding; a common view considering various perspectives is achieved. For these reasons, the focus group discussion was used in the context of this methodological toolbox and in order to summarize and, finally, check the primary data (Crowther & Lancaster, 2008).

What are the focus group guidelines and the focus group process?

In order to ensure an optimal discussion, 12 participants were chosen. Referring to the recommendations in the literature, this is the optimal group size for achieving fruitful discussions und to ensure, in parallel, the possibility for the moderator to interact (Creswell, 2014). Based on 5 main open-ended questions, the results were then summarized. Therefore, these questions were based on the developed business model and the quantitative data analysis obtained. The questions were composed to facilitate fruitful discussions and explore issues in depth. The intended study focus was borne in mind throughout and a quality check with two experts was made in advance. These experts have similar characteristics compared to the focus group. Via this pilot check, the intention was to guarantee a successful focus group discussion and to use the full range of group dynamics. There was a moderator, who commenced with a brief introduction, including discussion rules. The participants were pre-informed about the recording of the discussion; and despite their agreement obtained in advance, it was stated again that for evaluation results the discussion would be recorded. This included the possibility for the participants to read the summary after the session in the context of a clear feedback loop. In order to use the full range of advantages of a focus group, colleagues were asked to join the focus group session as well, especially to obtain a parallel view on the discussion and also to observe and collect non-verbal information and behaviours. In particular, via their support, the intention was to manage to process and to be able to control the overall debate while avoiding bias. In this context, it is extremely important to arrange a discussion atmosphere, which facilitates the overall dialogue (Creswell, 2014).

What are the key-learnings from focus group?

The key learnings from the focus group are the quality of the data and the possibility of generating innovative ideas, which clearly depends on the interaction. This interaction really influenced the data obtained during the focus group session. The use of open-ended questions are important to give the participants the opportunity to express themselves and to lead to a wide variety of very creative ideas. It is important to bear always in mind that the questions used should not automatically lead to a specific answer. Such leading questions otherwise automatically lead the participants to a specific answer. The reason for this is the content, structure or a specific wording that always leads in a certain direction and, therefore, influences the respondents positively or negatively. Therefore, this is not a bias-free questioning; neither is it a collection of statements. In this project, it was crucial not to use questions that led people to answer in a certain direction. This is especially important in order to ensure research reliability.

FURTHER ATTACHMENTS

- **Primary data collection – attachments**
- **Research Conference 2020 – poster Judith Karl**
- **Business Model Canvas | derived business model framework for a public charging station – the future mobility hub**

Judith Karl | Research Project
Judith.Karl@t-online.de
0049 | 163.300.111.7

Interview research project Judith KARL:
A sustainable business model for public charging stations in Germany - as key enabler for electric mobility

Date of the interview	
Name | interviewee	
Company	
Contact details	
Professional background	

1.) According to a current McKinsey study, the lack of efficient and widespread charging infrastructure is one of the most serious barriers regarding the purchasing decision for an electric vehicle. What do you think about that; please consider other buying potential barriers such as price, driving range or further criteria?

2.) Which scenario for electrical vehicle charging do you think will be the future priority, the public-centred scenario or the home-centred scenario?
Please describe the reasons behind your scenario and summarize your trend expectations for Germany?

3.) Which impact dimensions do you consider as key enablers for a successful public charging infrastructure? Examples could be price transparency of e-mobility electricity, user convenience, etc.

4.) Which main market and business models do you see for rolling out public charging infrastructure in Germany and why do you see them as the driving ones?

5.) From your point of view, what are the main success factors for a company to develop its innovative business models related to charging stations?

Judith Karl | Research Project
Judith.Karl@t-online.de
0049 | 163 300 111 7

Edinburgh Napier UNIVERSITY

Details | interviewee	
Date of the interview	
Name	
Company	
Contact details	
Professional background	

	1 | - not at all & no positive effect on a charging business case **10 | + entirely positive** effect on a charging business case	**-**	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**+**
1.	**Is this having a positive effect on electric charging business cases?** People not only buy a greener car; they also really change their **travel behaviours.**												
2.	Is this a trend with positive influence on charging business models? Shifting away from vehicle ownership to **multi-modal mobility and mobility as a service.**												
3.	Due to current developments, the future charging station is a **mobility hub.** Do you agree?												
4.	Do you agree that the complexity of operating interrelated business models and their underlying mechanisms is of particular interest in the **new sharing economy?**												
5.	Profitable business models can be achieved in conjunction with **other service components,** e.g. offering shopping or leisure activities. Do you agree?												
6.	Do you agree that some **business models from other branches** could inspire sustainable concepts for public charging infrastructure? Could they also be a clear benchmark-approach? E. g. Automotive business, 3D-printing technologies, aerospace or wind turbines												
7.	What do you think about the development that more and more **automobile manufacturers** will integrate the operation of charging stations as key business model? E. g. Tesla's proprietary Supercharger Network. Does this represent an overall and successful trend for you?												
8.	Is integration in a public or private **power grid** as key success factor?												
9.	Is effective **load management** as key success factor?												
10.	Is the market-related **availability and price-based competitiveness of greener cars** is of high importance?												
11.	**Sufficient charging population** and operating data e.g. charging amounts /- frequency is of key importance for a successful business model. Do you agree?												

	1 | - **not at all & no positive** effect on a charging business case 10 | + **entirely positive** effect on a charging business case	-	1	2	3	4	5	6	7	8	9	10	+
12.	Recently, electric vehicle charging infrastructure has seen **fundamental cost declines,** in particular due to new technological innovation. Do you agree?												
13.	What is your opinion about: "Early electric vehicle charging infrastructure was not systematically placed in Germany and is, thus, negatively affecting business models?" Issues are, e.g.: **numerous types of infrastructure and power supply standards.**												
14.	What is your opinion about: "Early electric vehicle charging infrastructure was not systematically placed in Germany and is, thus, negatively affecting business models?" Issues are, e.g.: **heterogeneous payment standards** at charging points run by different operators.												
15.	Vehicle ramp-up in Germany is much stronger than the continued development of the publicly accessible charging infrastructure, which is stagnating at present. Do you think **governmental incentives** are suitable instruments to boost public infrastructure in the medium term?												

Participant Information Sheet | Online Survey

Research project Judith KARL:
A sustainable business model for public charging stations in Germany -
as key enabler for electric mobility

I would like to invite you to take part in my research project.

Before you decide whether to take part it is important that you understand why the research is being done and what it will involve. Please take time to read this carefully and ask the researcher if you have any questions. Talk to others about the study if you wish. You will have at least five days to decide if you want to take part. I really appreciate your support for this research project; hopefully it will contribute to the development of a path towards electric mobility in Germany.

In case of questions in advance, please contact: Judith.Karl@t-online.de

1. **What is the purpose of the study?**
   Radical- and architectural innovation on electric mobility and public charging:
   - Provide the parameters for a business model concept to enable electric mobility and public charging in Germany
   - In particular, identification of key criteria for the establishment of a business model framework for the future public charging hub

2. **Why have I been invited to take part?**
   - I would like to invite you to participate in an online survey.
   - You will have received a link to an online survey, which has been sent to you by email and in completing the survey; you are participating in the research. Your views and experiences are very important in shaping the final resource by helping me to understand how business models are currently put into practice - concerning charging stations and as well other industrial examples

3. **Do I have to take part?**
   - No. It is up to you to decide whether you want to take part in this study. Please take your time to decide. If you decide to complete the online survey, you are consenting to take part in this phase of the research.
   - The information you share with me in the online survey will be confidential and anonymous and will only be used in this research project. You can withdraw from the study for up to two weeks after you have completed the online survey. If you wish to have your data withdrawn please contact the researcher and your data will then not be used | Judith.Karl@t-online.de.

4. **What will happen to me if I agree to take part?**
   - If you wish to take part in the survey, you can follow the link in the email sent to you. By completing the survey, you agree to take part in the research. A copy of the survey can be provided if you prefer.
   - The online survey will take approximately 20 minutes to complete and will ask you about your experiences in the following areas:
     - Some information about you; your role and professional experience
     - Your knowledge about electric mobility, charging stations and business models
     - How operator models are practiced, also with regards to other branches

5. **Are there any disadvantages and risks to taking part?**
   - The research does not involve any investigations or treatments that might put you at risk.

6. **Will the information I give stay confidential?**
   - Everything you say / report is confidential unless you tell me something that indicates that you or someone else is at risk of harm. I would discuss this with you before telling anyone else. The information you give, may be used for a research report, but it will not be possible to identify you from our research report or any other activities.
   - Personal identifiable information (e.g. name and contact details) will be securely stored and kept for up to three months after the project ends in February 2020 and then securely disposed of.
   - The research data (e.g. interview transcripts) will be securely stored.

7. **What will happen to the results of the research study?**
   - The findings of this study will be reported within my thesis.
   - They will also be presented at selected conferences.

Thank you for taking the time to read this information.

If you decide to take part or you have any questions, concerns or complaints about this study please contact me using the details below.

Judith.Karl@t-online.de
0049 | 163 300 111 7

Edinburgh Napier University | Research Consent Form

Edinburgh Napier University requires that all persons who participate in research studies give their written consent to do so. Please read the following and sign it if you agree with what it says.

1. I freely and gladly consent to be a participant in the research project on the following topic, to be conducted by Judith Karl, based at Napier University | Business School.
   Research project & topic:
   Radical- & architectural innovation about the electric mobility & charging solutions:
   - Providing the parameters for a business model concept to enable electric mobility and public charging in Germany
   - In particular identification of key criteria for the establishment of a business model framework for the future public charging hub
2. The broad goal of this research study is to explore charging stations against the background of operator models. Specifically, I have been asked to [survey/be interviewed/participate in a focus group], which should take no longer than [XXX] minutes to complete.
3. I have been told that my responses will be anonymised, unless I waive my right to anonymity. My name will therefore not be linked with the research materials and I will not be identified or identifiable in any report subsequently produced by the researcher. Participating in this study will in no way affect references.
4. I also understand that if at any time during the [survey/interview/focus group] I feel unable or unwilling to continue, I am free to leave. That is, my participation in this study is voluntary and I may withdraw without negative consequences. However, after data has been anonymised or after publication of results, it will not be possible for my data to be removed as it would be untraceable at this point.
5. In addition, should I not wish to answer any particular question or questions, I am free to decline.
6. I have been given the opportunity to ask questions regarding the research and my questions have been answered to my satisfaction.
7. I have read and understand the above and consent to participate in this study. My signature is not a waiver of any legal rights. Furthermore, I understand that I will be able to keep a copy of the informed consent form for my records.

Participant's Signature Date

I have explained and defined in detail the research procedure in which the respondent has consented to participate. Furthermore, I will retain one copy of the informed consent form for my own records.

Researcher's Signature Date

Napier Research Conference 2020, event cancelled due to Covid-19

Research Conference 2020 – poster Judith Karl

Business Model Canvas | derived business model framework for a public charging station – the future mobility hub (own illustration, taking into account Osterwalder & Pigneur (2010).

<table>
<tr>
<td rowspan="2">KEY PARTNERS

• IT-service providers
• Energy providers and utilities
• Suppliers of fossil fuels
• Mobility service providers
• Shop-suppliers
• Restaurants & franchising partners
• Advertising customers
• Large scale enterprises, paying services for their employees
• Research intitules
• Mobility associations
• Entrepreneurs
• Investors
• Cities and local governments
• Parcel services and dispatch companies
• Car manufacturing companies</td>
<td>KEY ACTIVITIES

Provision of multi-modal, sustainable mobility services - services to be integrated:

• Private mobility services – sharing / renting systems – car-sharing, car-pooling, bicycle rental, car hire

• Integrating public transport services (public transport, taxi, on-demand bus services) - achieving comprehensive mobility opportunities for society

Additional components to be integrated:

• Billing systems and payment services
• Mobility planning
• Parking services
• Logistics services
• Routing services
• Bicycle boxes and package boxes</td>
<td rowspan="2">VALUE PROPOSITION

• Charging and mobility hub, offering charging and combining multi-modal transport services
• Offering comprehensive services e. g. for the vehicle, shopping facilities; to enable consumers to use the charging time as effectively as possible

➔ The customer contact resulting from charging infrastructure is used for other electric mobility business models and multi-modal mobility services

• Charging performance and well-designed multi-modal mobility services
• Taking the future development of mobility into account
• Reliability
• Flexibility
• Environmental awareness
• Safety, convenience, accessibility
• Price-consciousness</td>
<td>CUSTOMER RELATIONSHIP

• Personalization option for services, charging and especially new multi-modal mobility services

• Customization allows the end-user to tailor the service option offered to his needs based on individual preferences

➔ Positively influencing sales and marketing and the company’s reputation & brand value</td>
<td rowspan="2">CUSTOMER SEGMMENTS

Electric mobility users, according to the expected service level

Customers for:

• Charging services
• For business- and fleet customers
• For private clients

• E-mobility- and multi-modal mobility services | business- and fleet customers B2B

• E-mobility- and multi-modal mobility services | private clients

• Vehicle-related services

• Additional services</td>
</tr>
<tr>
<td>KEY RESOURCES

• IT Competence
• User orientation
• Service design</td>
<td>CHANNELS

• Digital platform and website, mobile App enabling digital services
• End-user gets access to all services necessary for charging, travel planning, booking, ticketing, payment and further real-time information</td>
</tr>
</table>

COST STRUCTURE		REVENUE STREAMS
• Fixed costs, such as costs for the initial investment rental costs and/or lease costs, energy costs, any license fees, maintenance costs and personnel costs • Other probable fixed costs positions can be: IT-infrastructure and -application, customer support, sales and marketing, contract management • Variable costs are incurred for operating materials and the purchase of goods and services		• Offering multi-modal and personalized mobility services, including charging with regards to the future fuel mix • Contracts with service providers, e. g. with restaurants and shops • Supplemented by advertisements - generating further revenues • Contracts with end-users, e. g. various approaches flat rate | Mobility SmartCard • Value driven pricing
SUSTAINABILITY • Public charging infrastructure development has profound significance on sustainability, resulting also in positive economic effects • Charging infrastructure is an important basis for the widespread use of electric vehicles and reducing environmental effects on society • The future mobility hub, offering mobility as a service, encourages road users to use modes of transport other than the car more often, which is ultimately the most effective measure for the transition to sustainable mobility		

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